Ch 3 Atoms

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Aristotle - 4 elements → Theory

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↳ atomos - atom

Aristotle - 4 elements → water, fire, earth, air Theory

Alchemy - early chemistry

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↳ make Pb → Au

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↳ LCM

Dalton -

Dalton - Derived his atomic theory
Based on LCM, LDC

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1807

1. All matter is composed of atoms
2. atoms of the same element have the same props
" " different " " different "

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1807

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2. atoms of the same element have the same props ← Isotopes
   " " different " " different "
   ↳ same element w/ diff # of neutrons (# of n differs)

3. atoms cannot be created, subdivided, nor destroyed
   ↳ #93 ↳ in P, n, e⁻ ↳ E=mc²

4 Atoms combine in small whole # Ratios to form compounds

5. In Rxns, Atoms separate, Rearrange, & combine to form New compounds

1897 JJ Thomson

CRT

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CRT Cathode Ray Tube

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↳ Sealed Glass Tube w/ electrodes containing a gas @ low P

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when a current is applied to gas → see a beam

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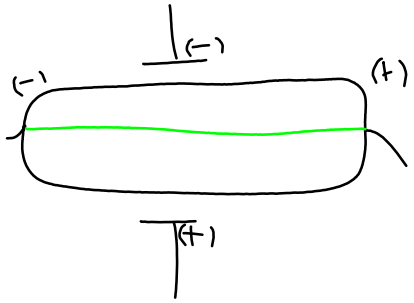

1897 JJ Thomson

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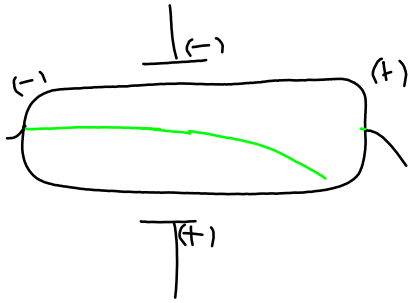

1. Beam deflected away from (−) charge

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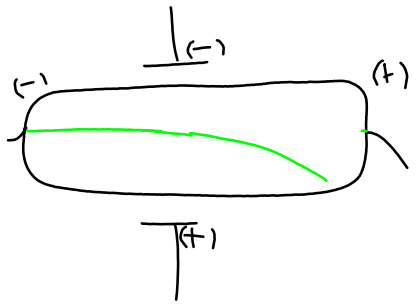

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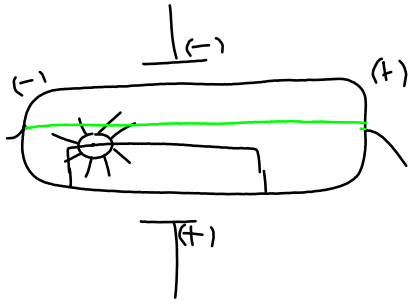

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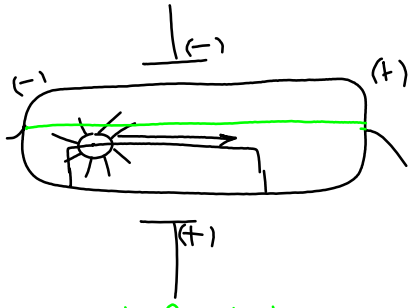

1. Beam deflected away from (−) charge → Beam is (−)
2. Beam moved paddle wheel toward (+) electrode →

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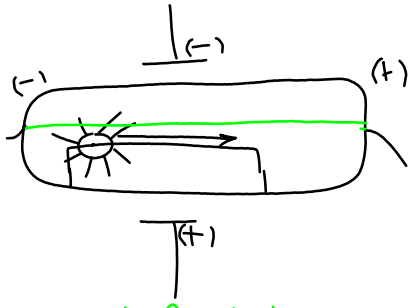


1. Beam deflected away from (−) charge → Beam is (−)
2. Beam moved paddle wheel toward (+) electrode → Beam is (−) particles
   ↳ the electron!

1897 JJ Thomson

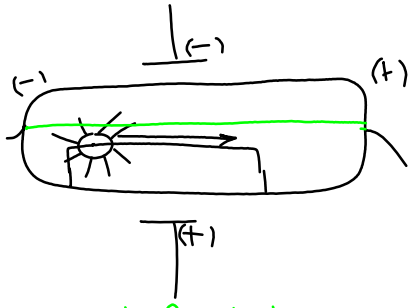
CRT Cathode Ray Tube

↳ Sealed Glass Tube w/ electrodes containing

3. Thomson's graph below ↓

Charge: mass Ratio

↳ $1.76 \times 10^8 \frac{\text{Coulombs}}{\text{gram}}$ } Indicates V. Small MASS



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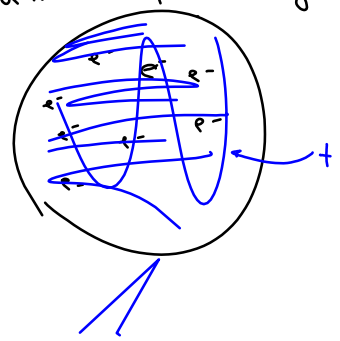
↳ the electron!

1911 Robert Millikan

↳ measured charge of e⁻

Plum Pudding Model of the atom

↳ atoms are e⁻ floating in a matrix of + charge



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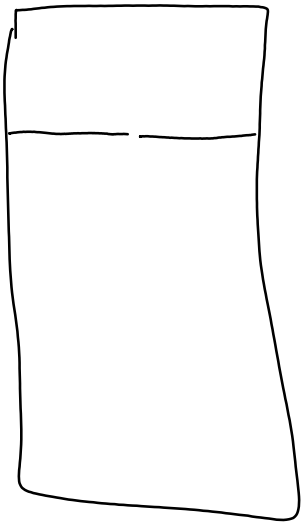

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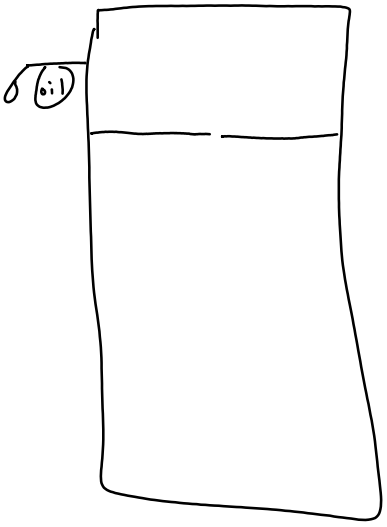
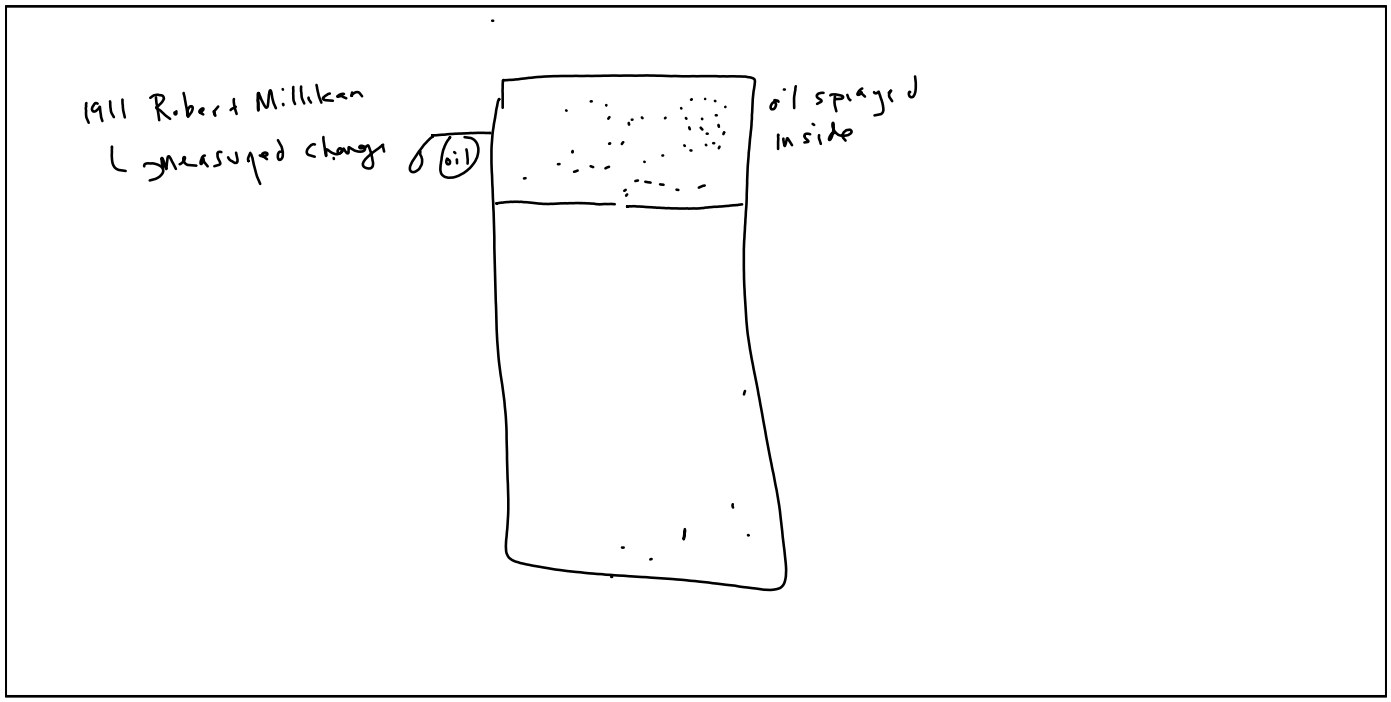
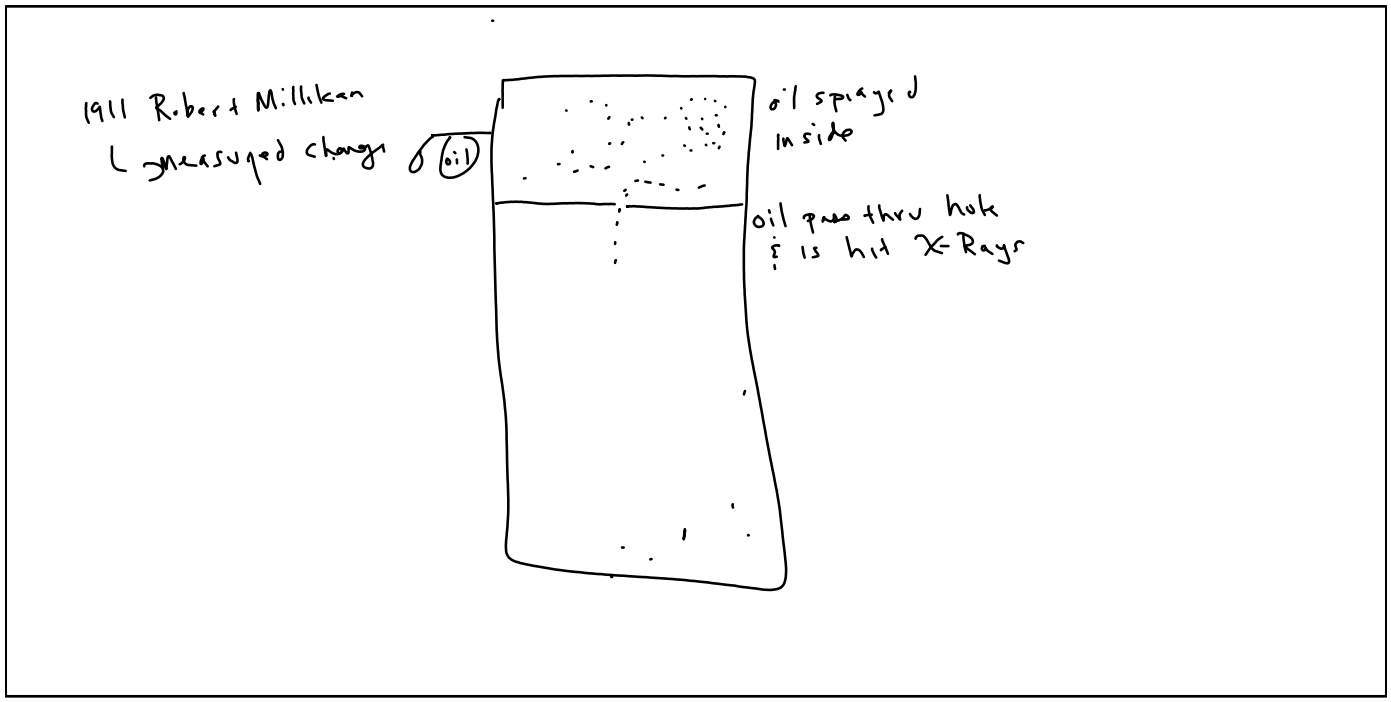
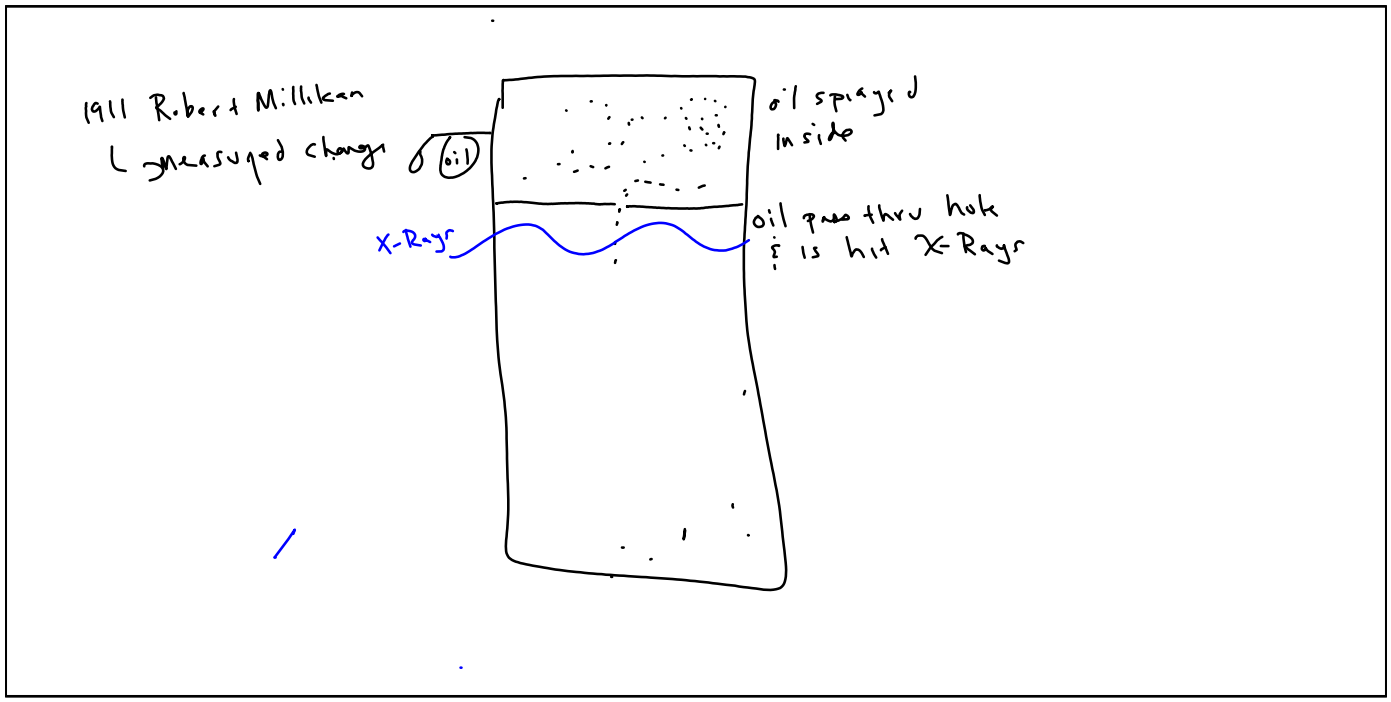
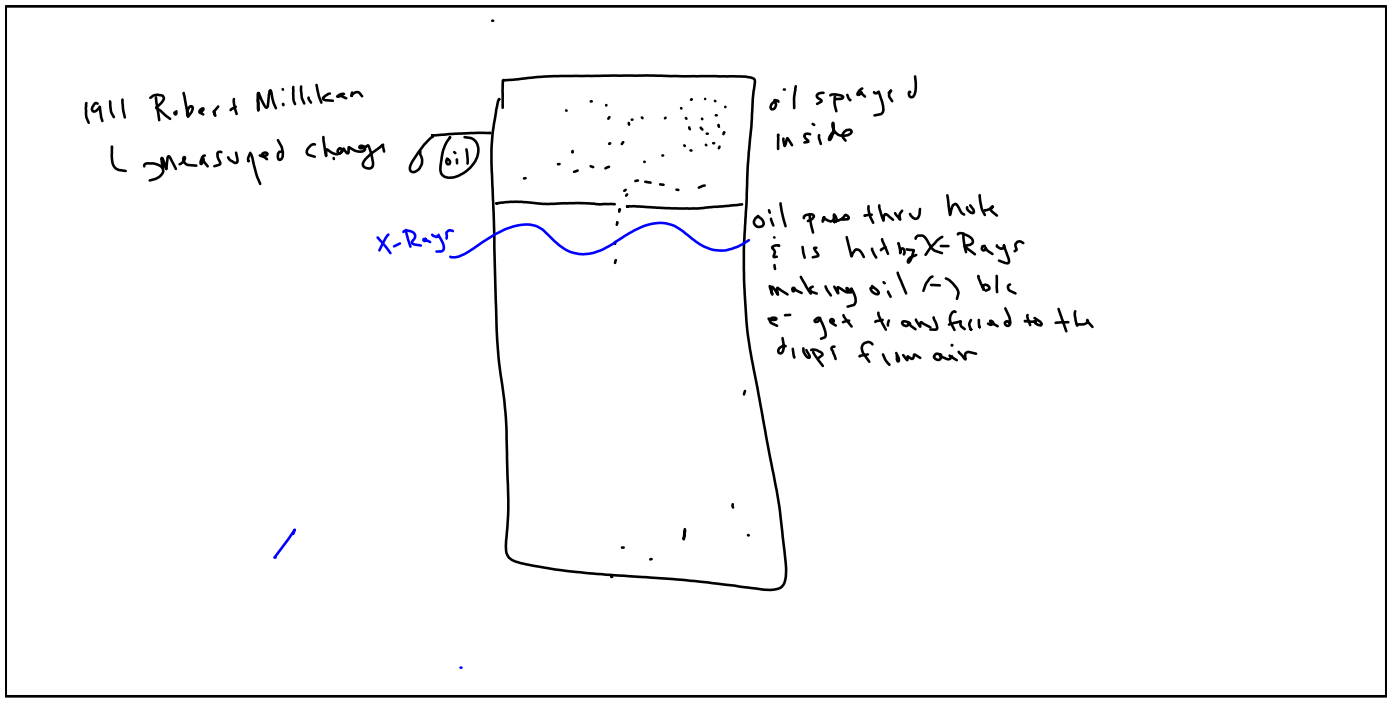
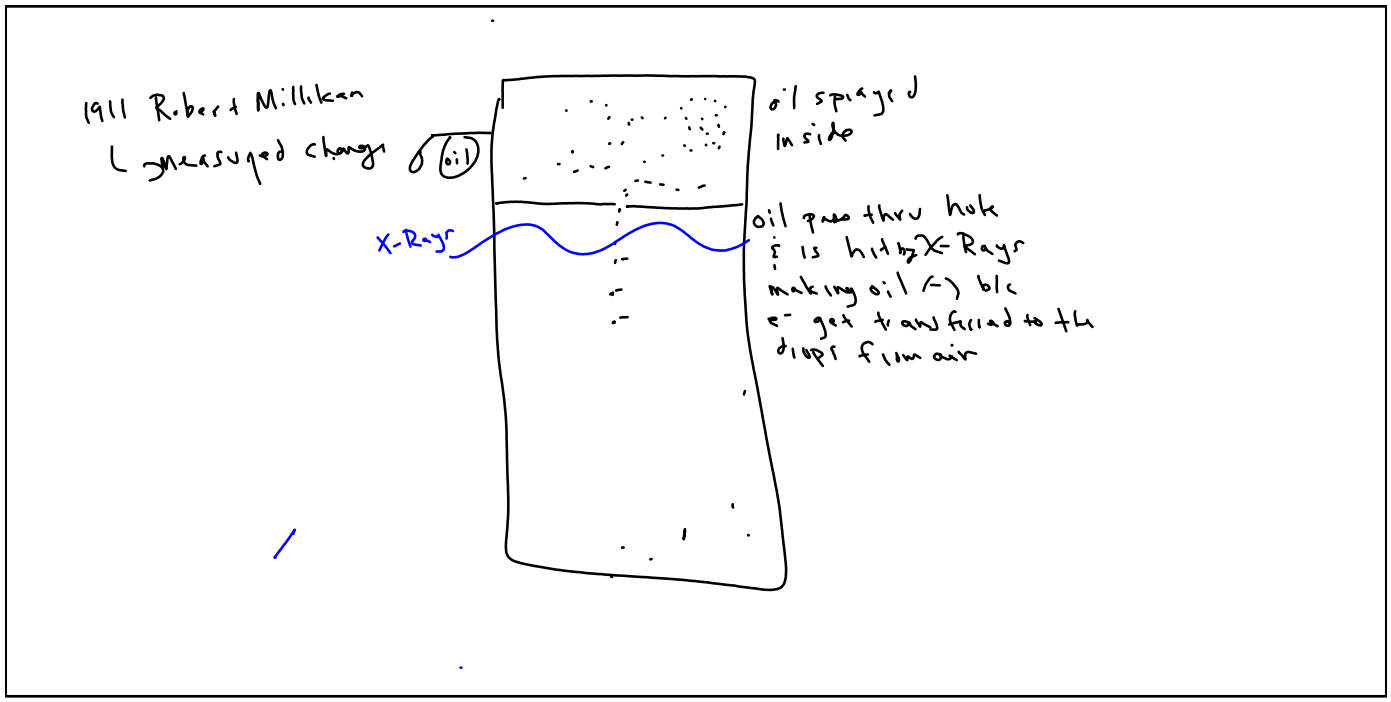



1911 Robert Millikan
measured charge
oil
oil sprayed inside


1911 Robert Millikan
measured charge
oil
oil sprayed inside
oil goes thru hole
is hit X-Rays


1911 Robert Millikan
measured charge
oil
oil sprayed inside
X-Rays
oil goes thru hole if is hit X-Rays


1911 Robert Millikan
measured charge
oil
oil sprayed inside
oil goes thru hole
it is hit by X-Rays
making oil (-) b/c
e- get transferred to the
drops from air
X-Rays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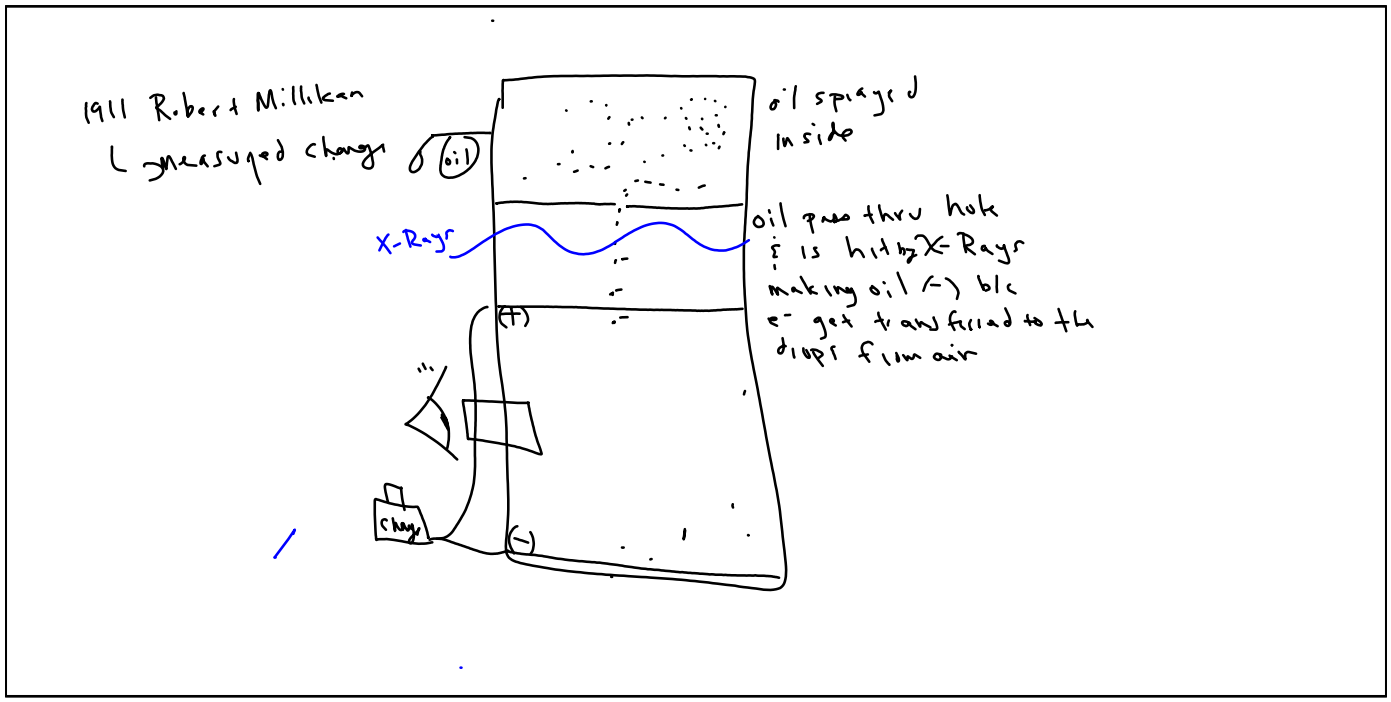
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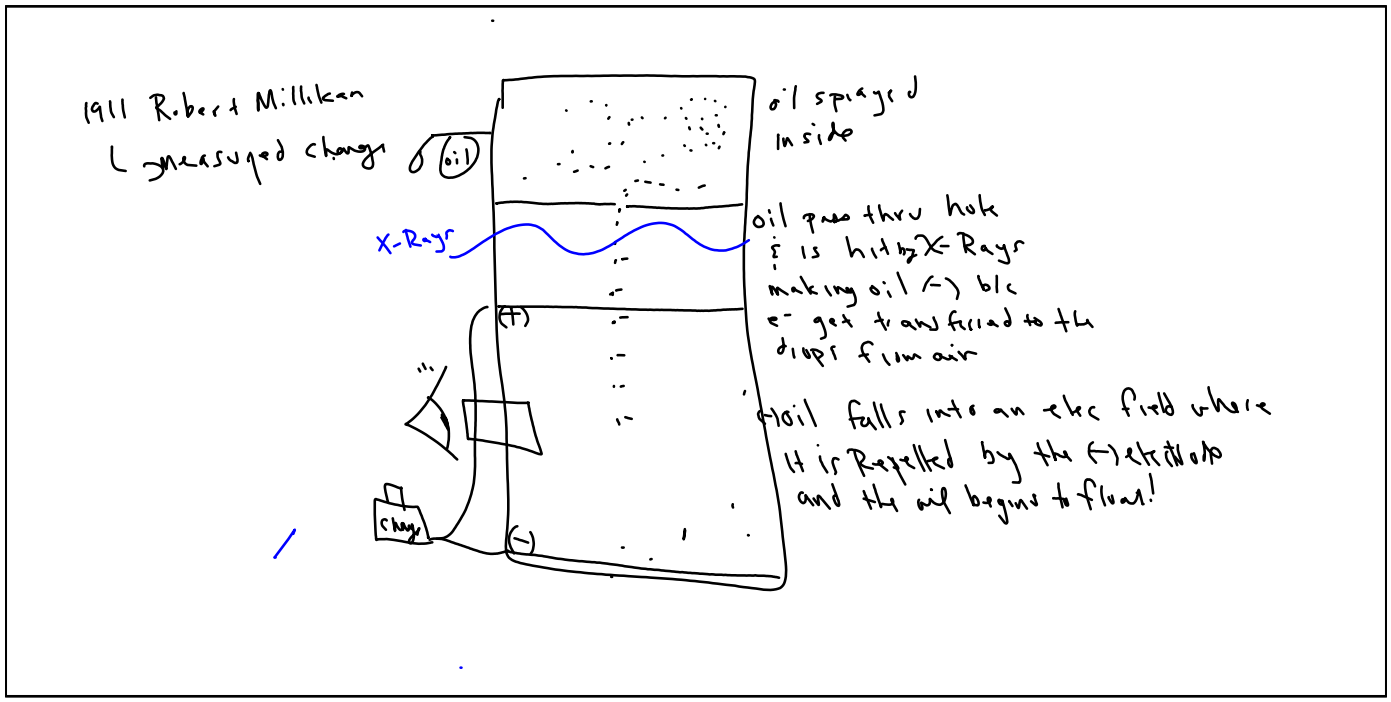
drops from air
(+)
(-)
charge


1911 Robert Millikan
measured charge
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(+)
(-)
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oil sprayed inside
oil goes thru hole
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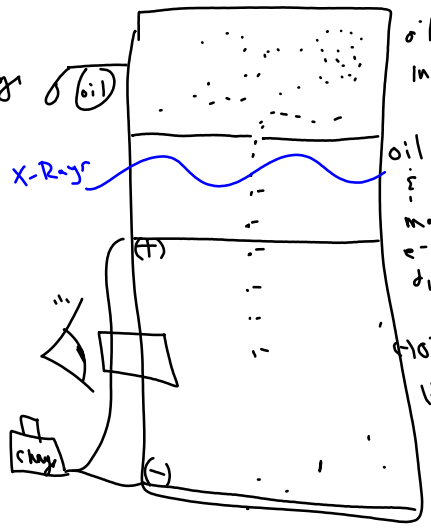
e- get transferred to the
drops from air
oil falls into an elec field where
it is repelled by the (-) electrode
and the oil begins to float!

1911 Robert Millikan
↳ measured charge

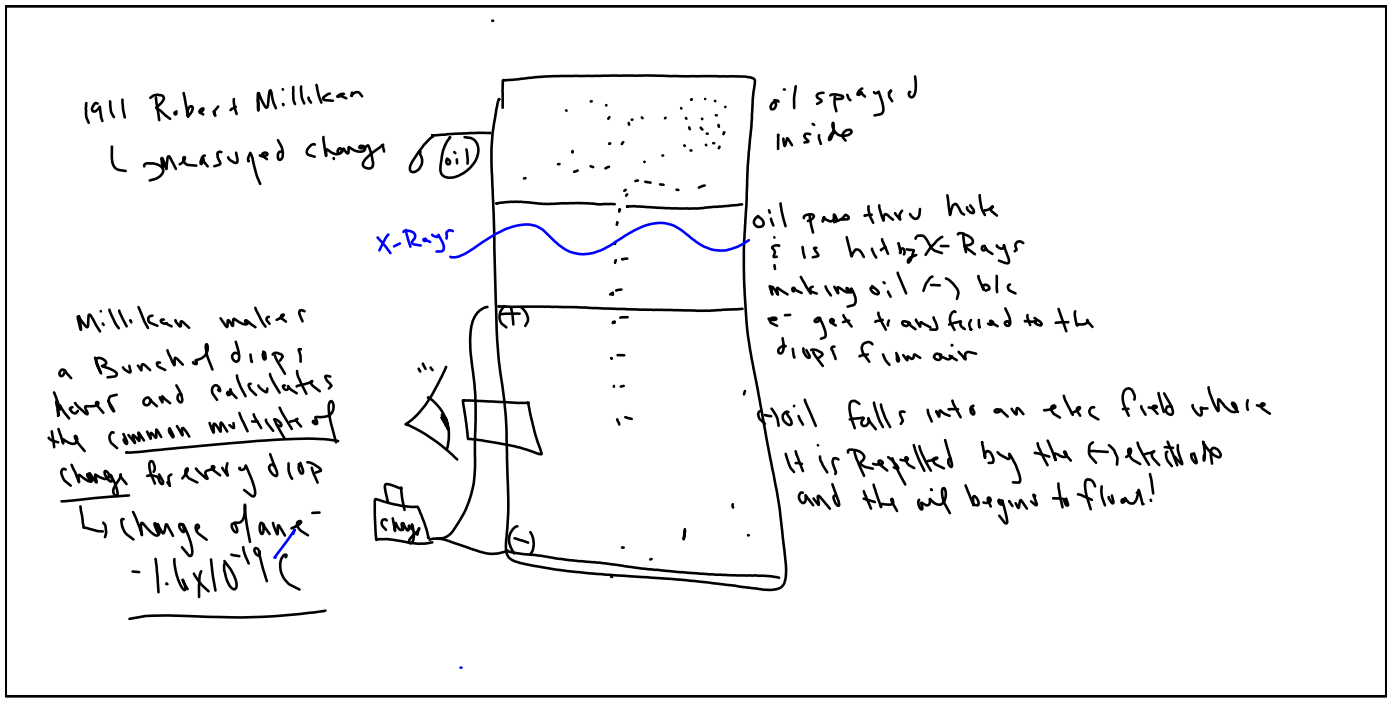


oil sprayed inside

oil goes thru hole
it is hit by X-Rays
making oil (-) b/c
e⁻ get transferred to the
drops from air

oil falls into an elec field where
it is repelled by the (-) electrode
and the oil begins to float!

Millikan makes
a Bunch of drops
& over and calculates
the common multiple of
charge for every drop
↳ charge of one e⁻


1911 Robert Millikan
↳ measured charge
Millikan makes a Bunch of drops later and calculates the common multiple of charge for every drop
↳ charge of an e⁻
-1.6x10⁻¹⁹C
oil
X-Rays
(+)
(-)
oil sprayed inside
oil goes thru hole it is hit by X-Rays making oil (-) b/c e⁻ get transferred to the drops from air
oil falls into an elec field where it is repelled by the (-) electrode and the oil begins to float!

charge → -1.6×10^{-19} C

Charge: mass $1.76 \times 10^{8} \frac{C}{g}$

charge → -1.6×10^{-19} C

charge: mass $-1.76\times10^{8}\ \frac{C}{g}$

$$\frac{-1.6\times10^{-19}\ C}{-1.76\times10^{8}\ \frac{C}{g}}$$

charge → -1.6×10^{-19} C

charge: mass $-1.76 \times 10^{8} \frac{C}{g}$

$$\frac{+1.6 \times 10^{-19} \text{ C}}{+1.76 \times 10^{8} \frac{\text{C}}{\text{g}}} =$$

charge → -1.6×10^{-19} C charge: mass → $1.76\times10^{8}\ \frac{C}{g}$

$$\frac{+1.6\times10^{-19}\ C}{+1.76\times10^{8}\ \frac{C}{g}} = 9.1\times10^{-28}\ g \leftarrow \text{mass of } e^-!$$

charge → -1.6×10^{-19} C charge: mass $-1.76\times10^{8}\ \frac{C}{g}$

$$\frac{+1.6\times10^{-19}\ C}{+1.76\times10^{8}\ \frac{C}{g}} = 9.1\times10^{-28}\ g \leftarrow \text{mass of e}^-!$$

$9.109\times10^{-28}\ g$

1908 - Ernest Rutherford
Gold foil Experiment

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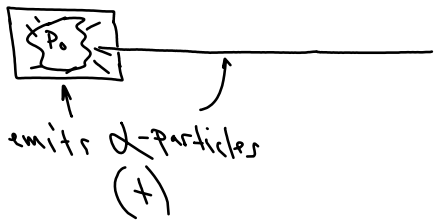
Gold foil Experiment



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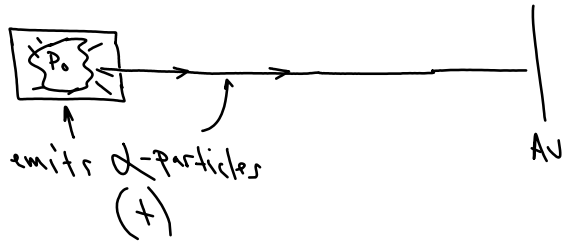

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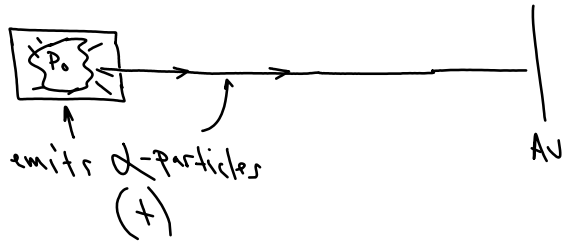
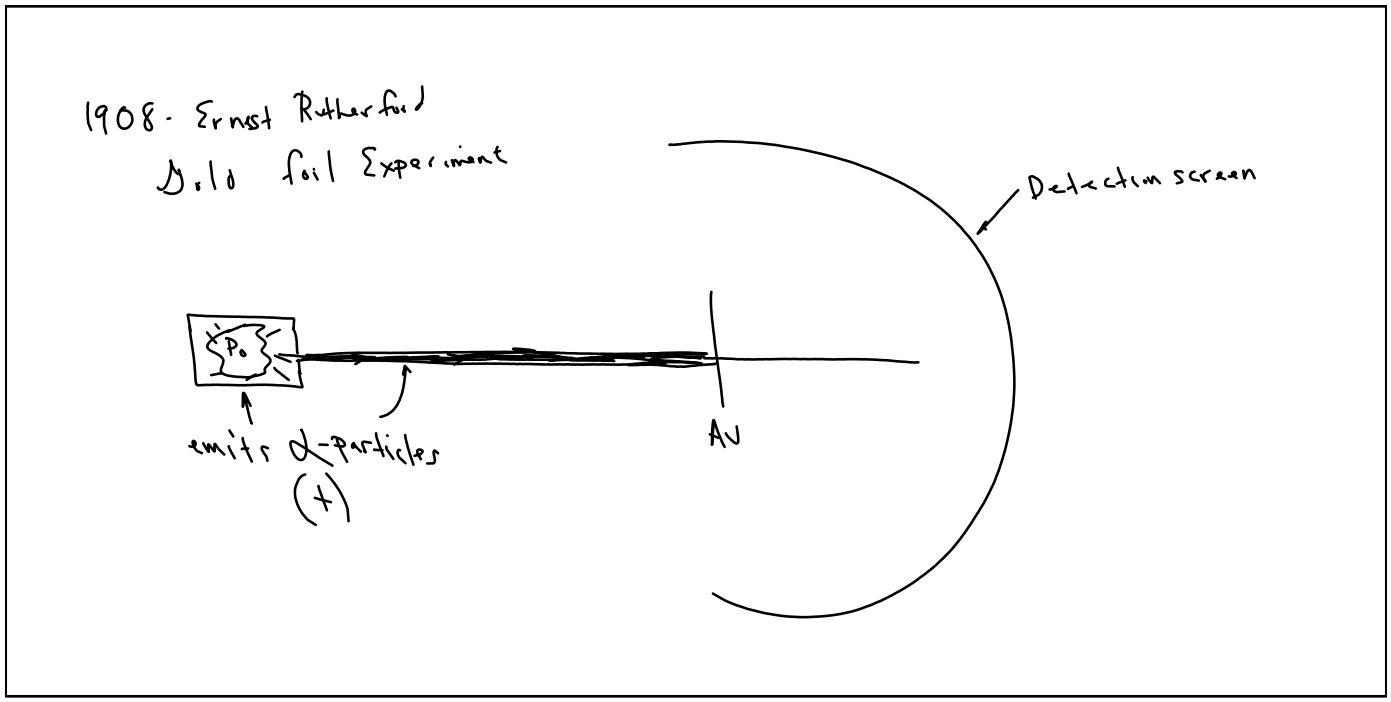
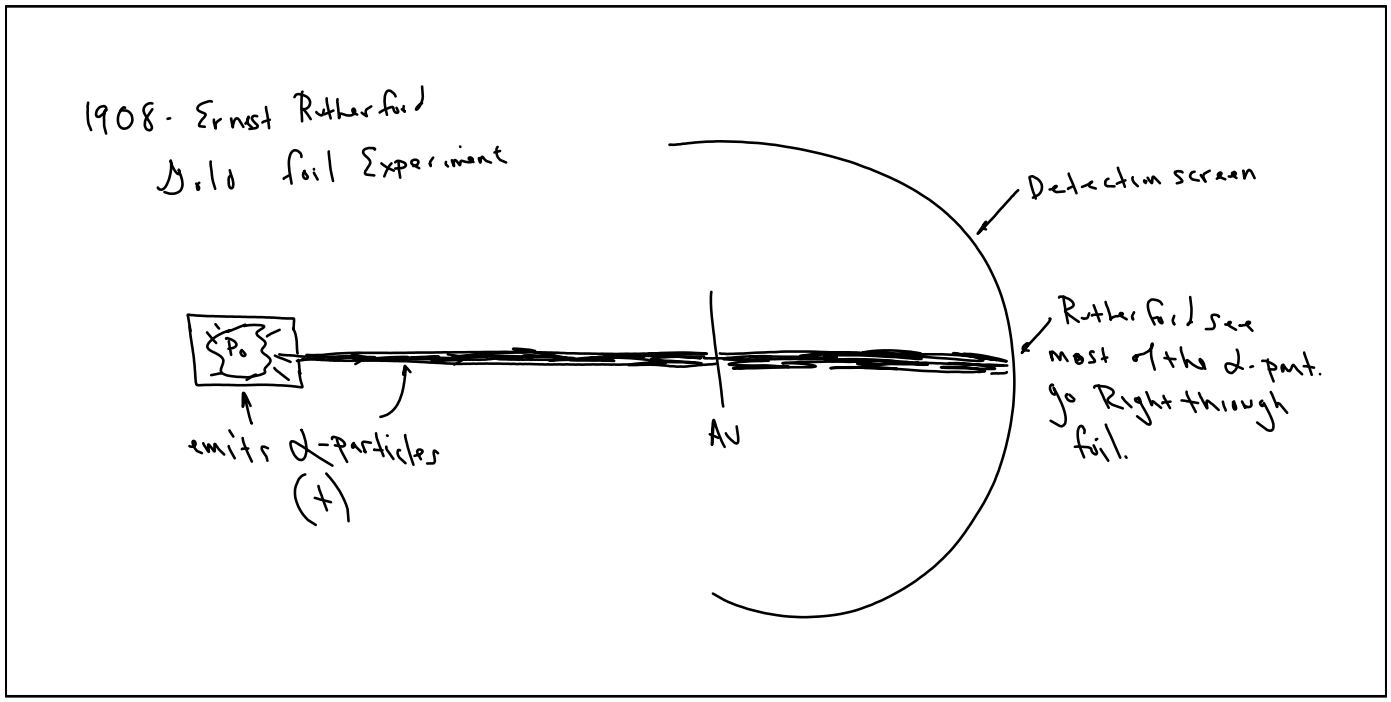
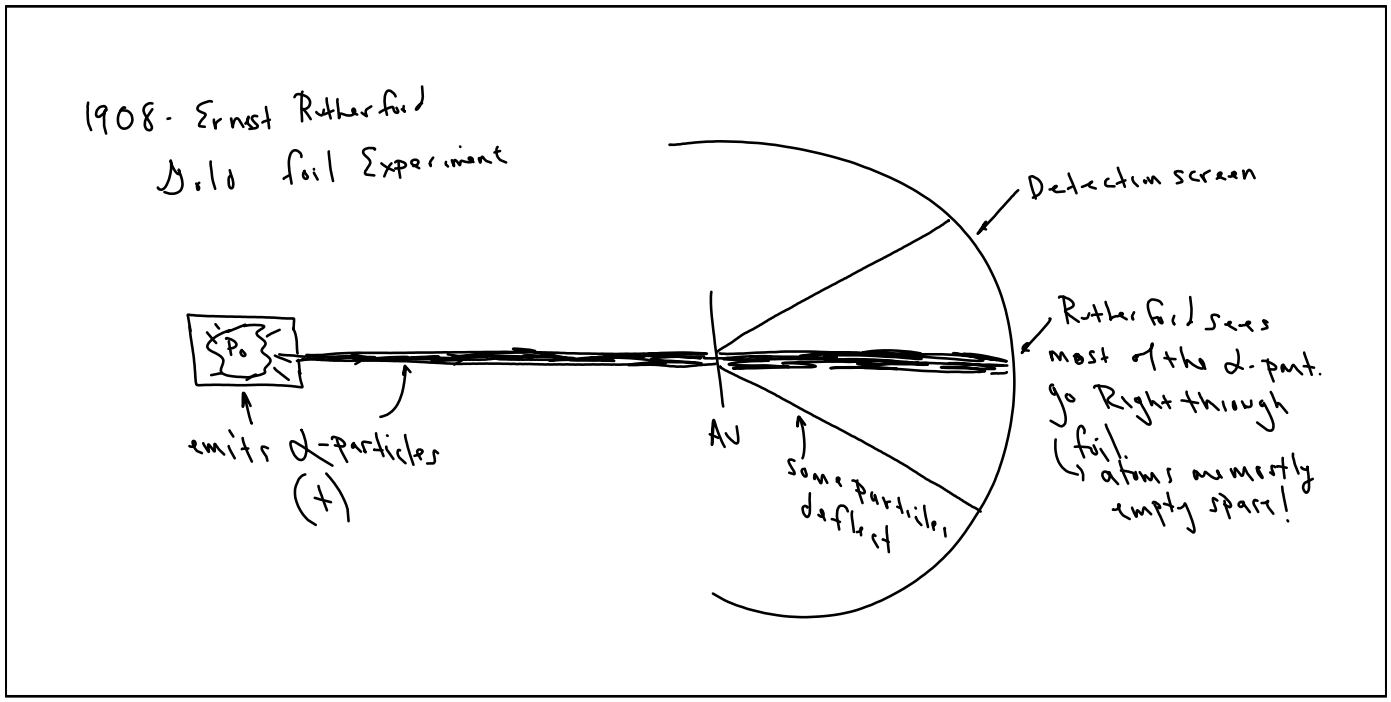
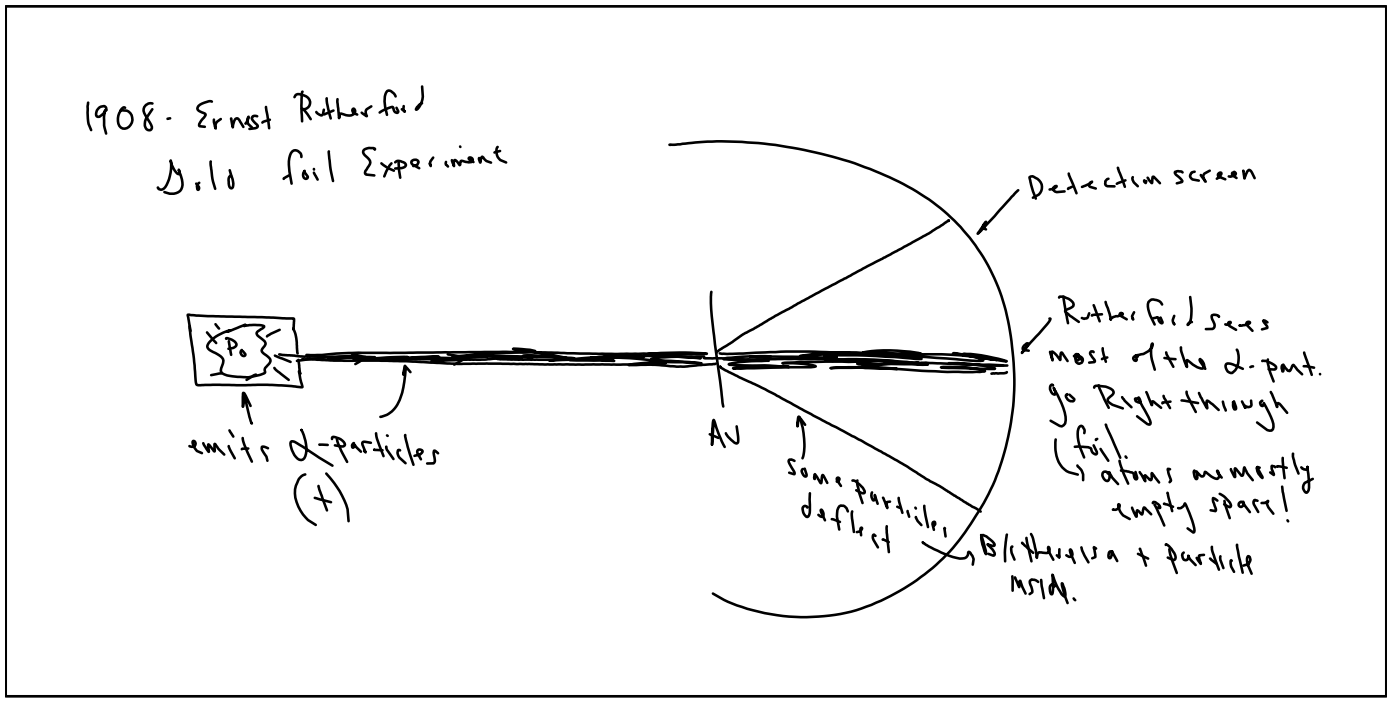



1908 - Ernest Rutherford
Gold foil Experiment
Detection screen
Po
emits α-particles
(+)
Au


1908 - Ernest Rutherford
Gold foil Experiment
Detection screen
Rutherford saw most of the α-part. go Right through foil.
Po
emits α-particles (+)
Au


1908 - Ernest Rutherford
Gold foil Experiment
Detection screen
Rutherford sees most of the α-part. go Right through (foil). ↳ atoms are mostly empty space!
Po
emits α-particles (+)
Au
some particles deflect


1908 - Ernest Rutherford
Gold foil Experiment
Detection screen
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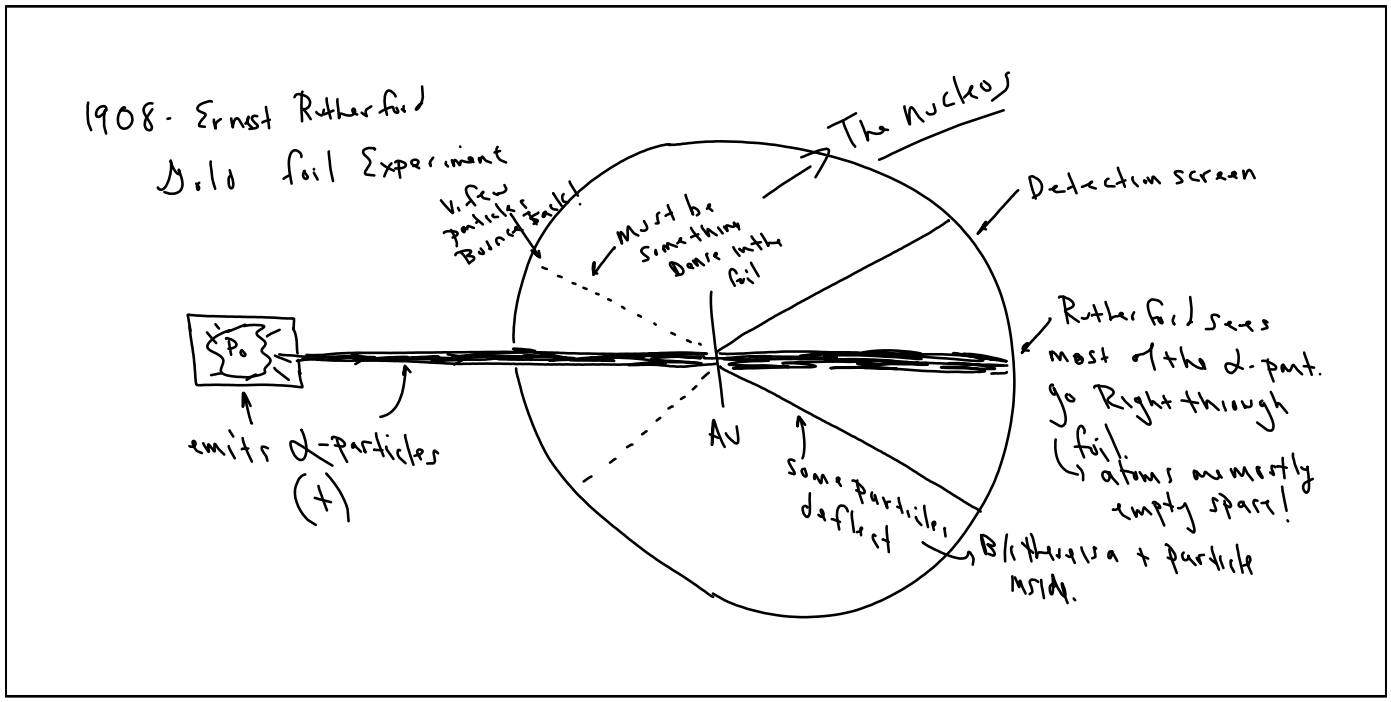
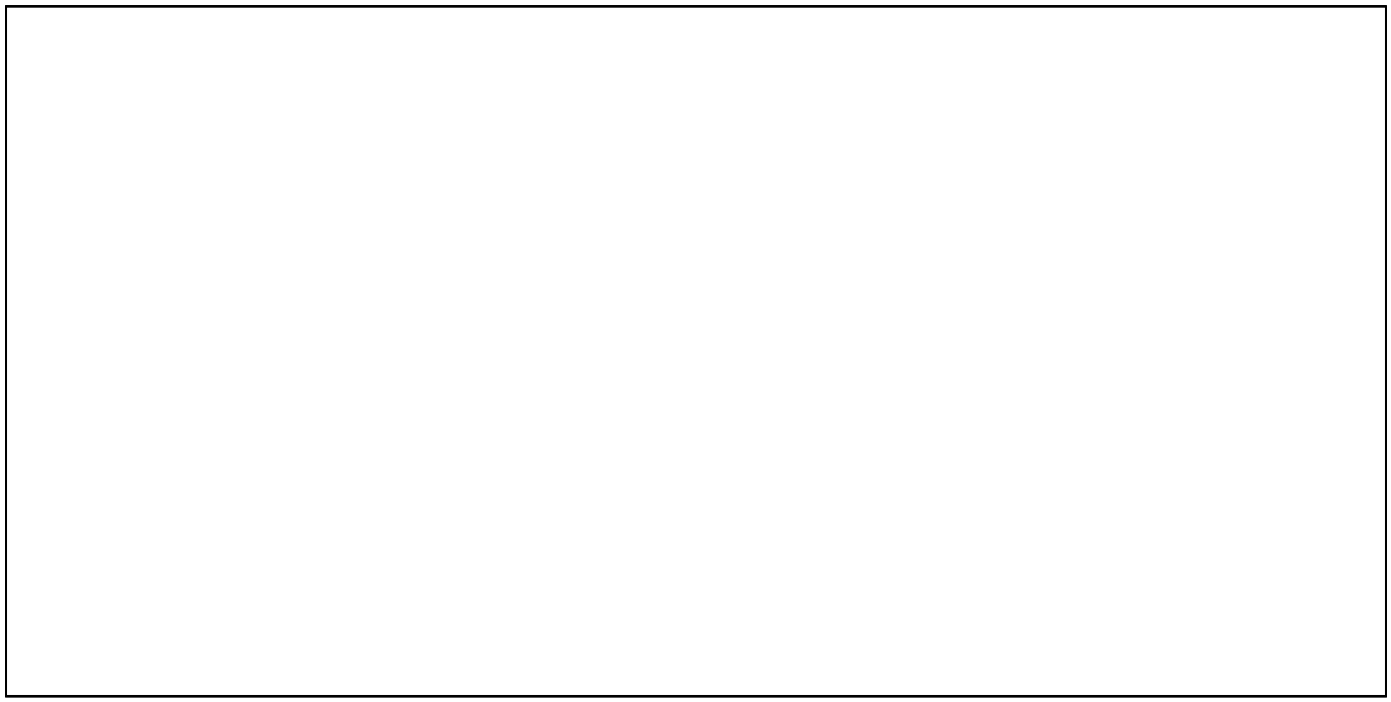
Po
emits α-particles (+)
Au
some particles deflect
& 1/8 through a + particle nuclei.

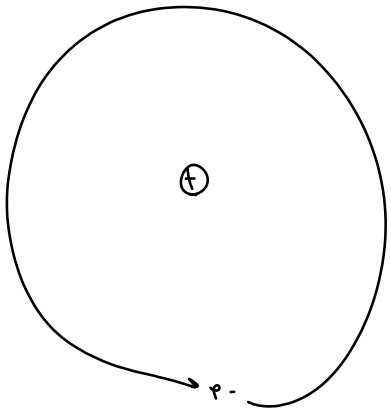

1908 - Ernest Rutherford
Gold foil Experiment
A few particles Bounced back!
The nucleus
Must be Something Dense in the foil
Detection screen
Rutherford sees most of the α-part. go Right through (foil). ↳ atoms are mostly empty space!
Po
emits α-particles (+)
Au
Some particles deflect
& Occasionally a + particle hits.



Rutherford's
Atomic Model

Rutherford's Atomic Model

e^- orbit the nucleus like planets orbit the sun



A tms

Atoms

protons

neutrons

electrons

Atoms

protons (p)

neutrons (n)

electrons (e^-)

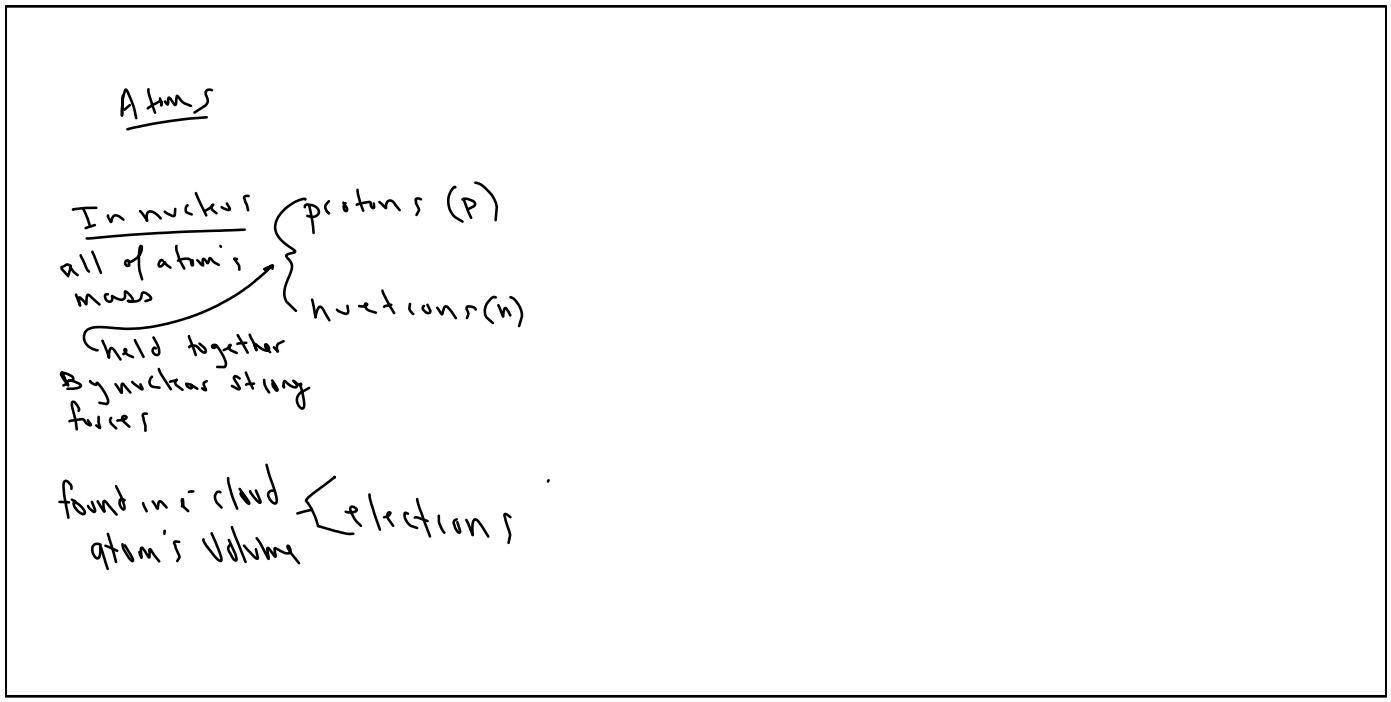
Atoms

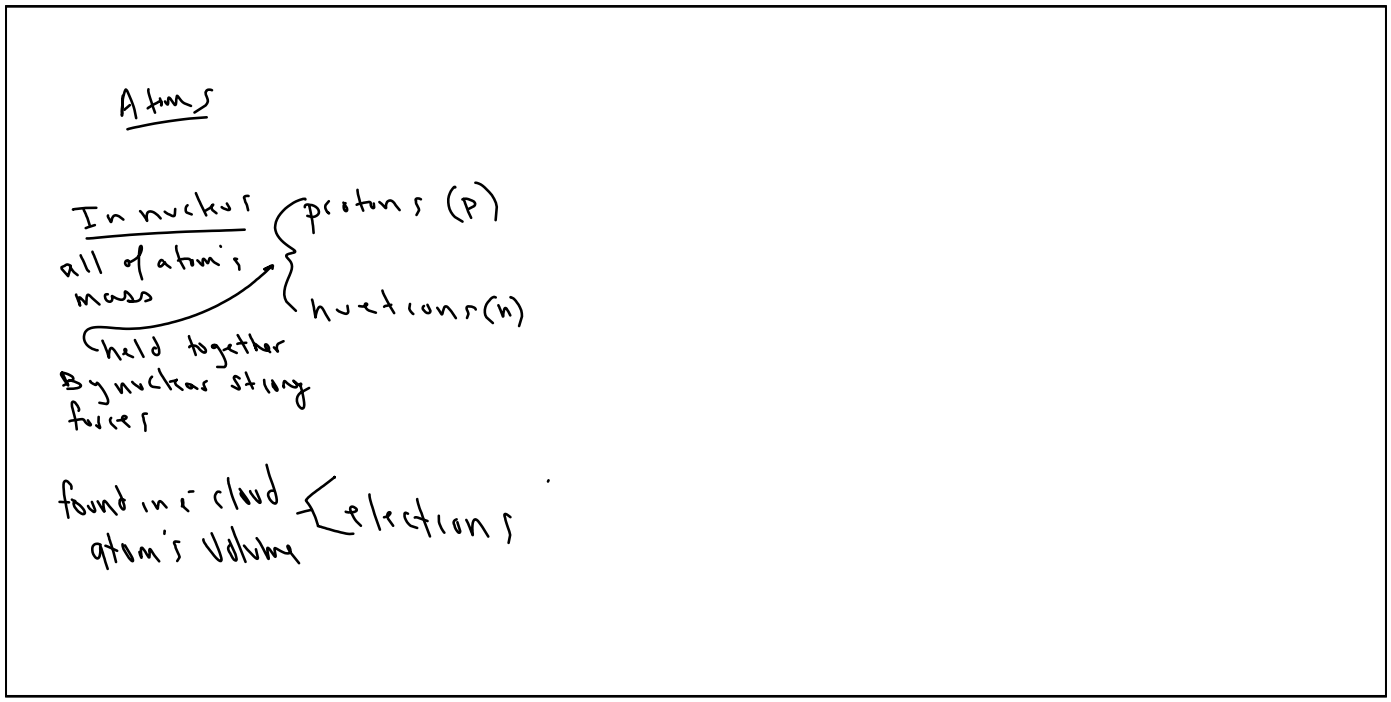
In nucleus all of atom's mass { protons (p), neutrons (n)

electrons (e^-)

Atoms

In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
neutrons (n)
electrons (e^-)


Atoms
In nucleus
all of atom's mass
protons (P)
neutrons (n)
held together
By nuclear strong forces
found in e⁻ cloud
atom's Volume
electrons


Atoms
In nucleus
protons (P)
all of atom's mass
neutrons (n)
held together by nuclear strong forces
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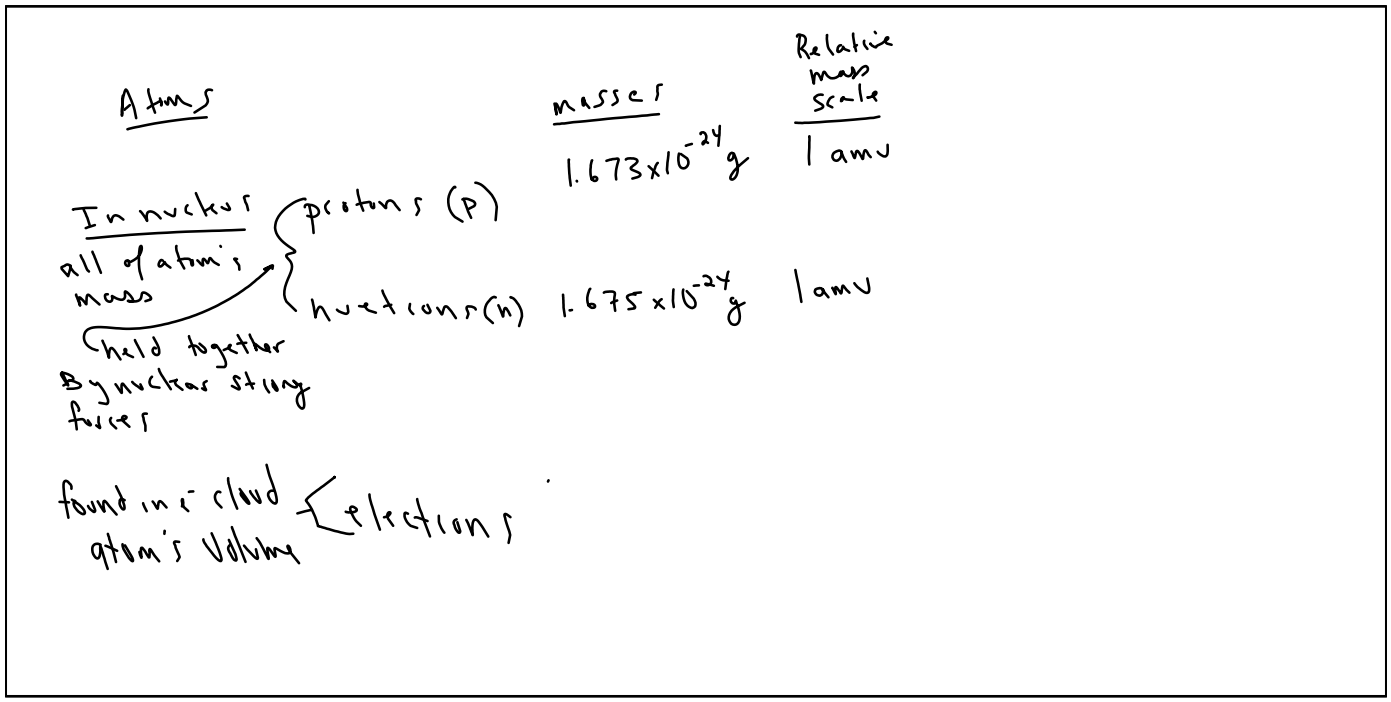
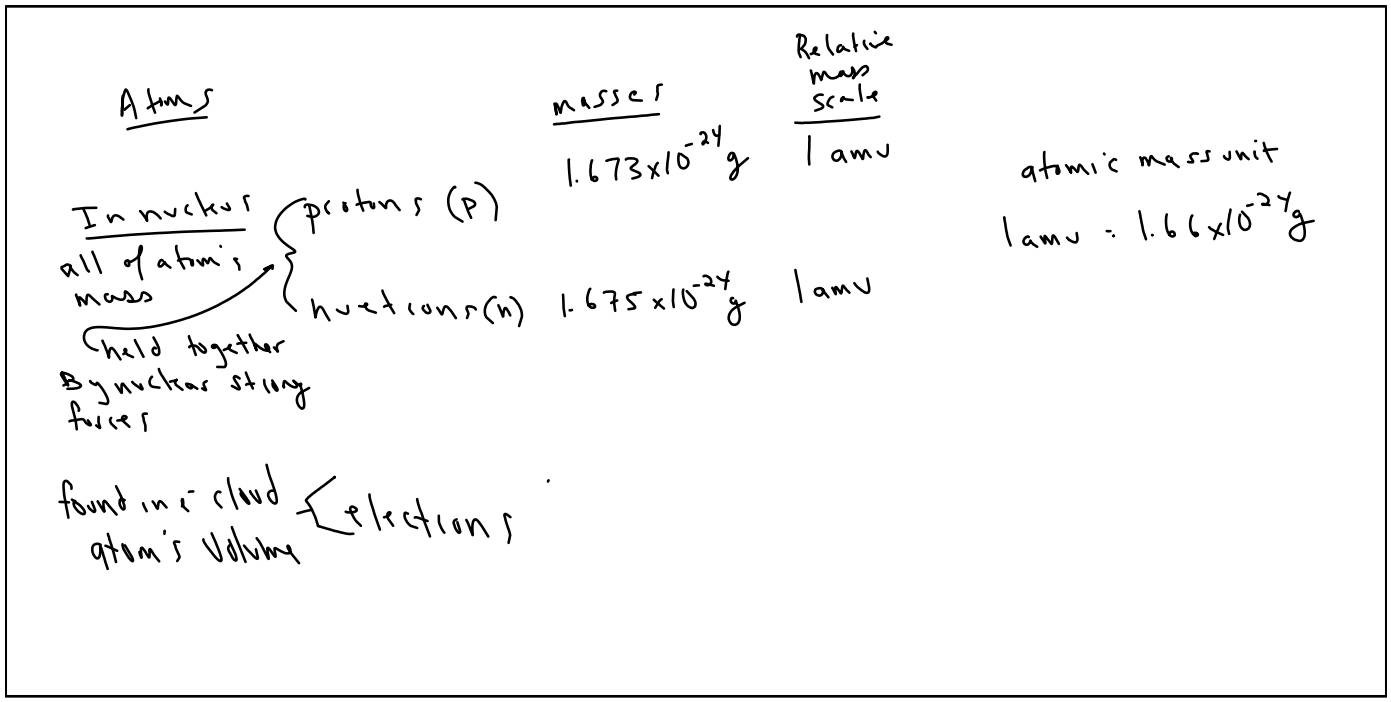
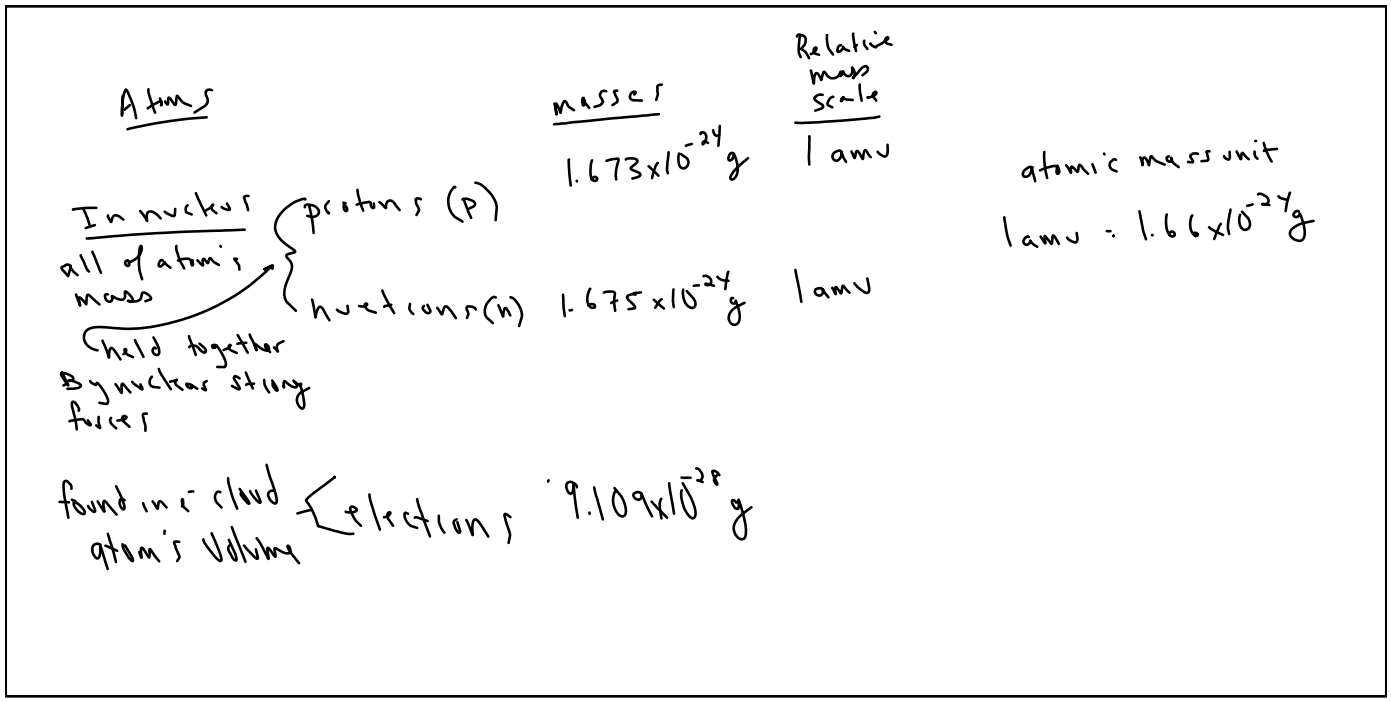
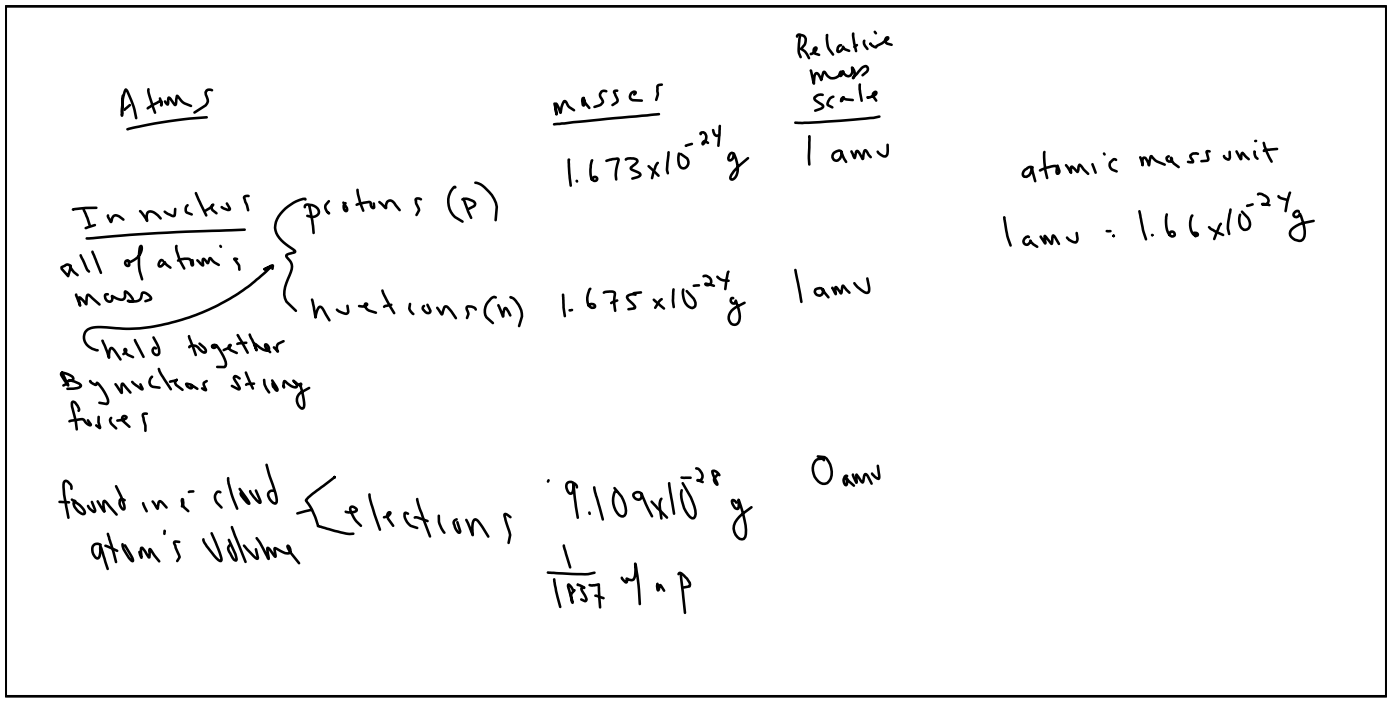
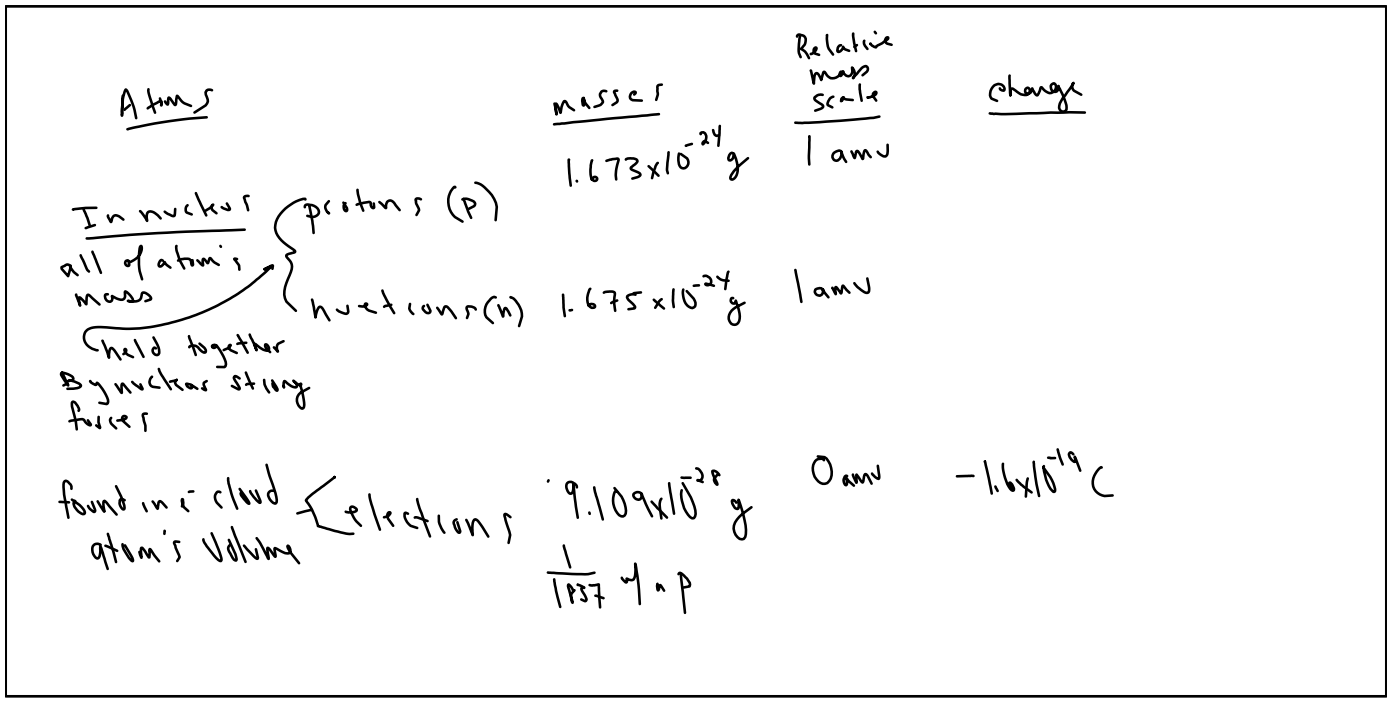
electrons
atom's Volume

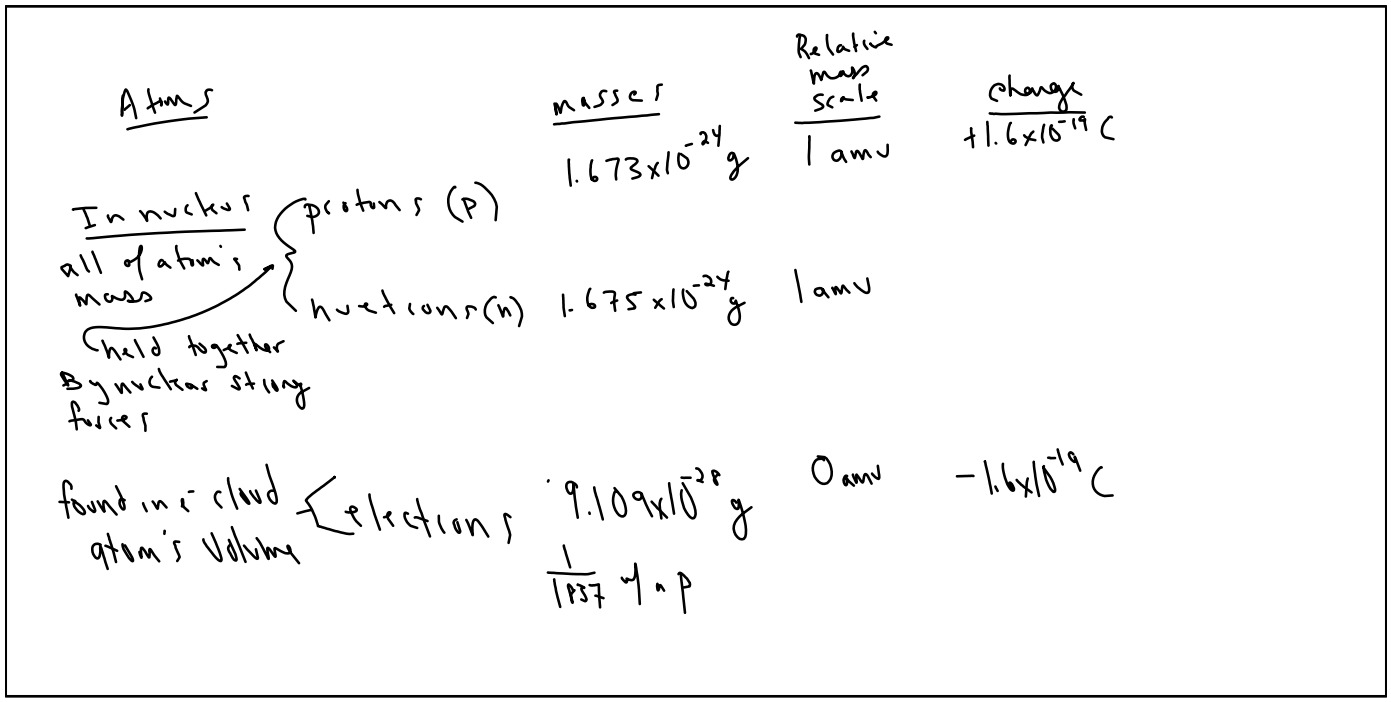

Atoms
masses
Relative mass scale
1.673x10^-24 g
1 amu
In nucleus
all of atom's mass
protons (p)
neutrons (n)
1.675x10^-24 g
1 amu
held together by nuclear strong forces
found in e- cloud
atom's Volume
electrons

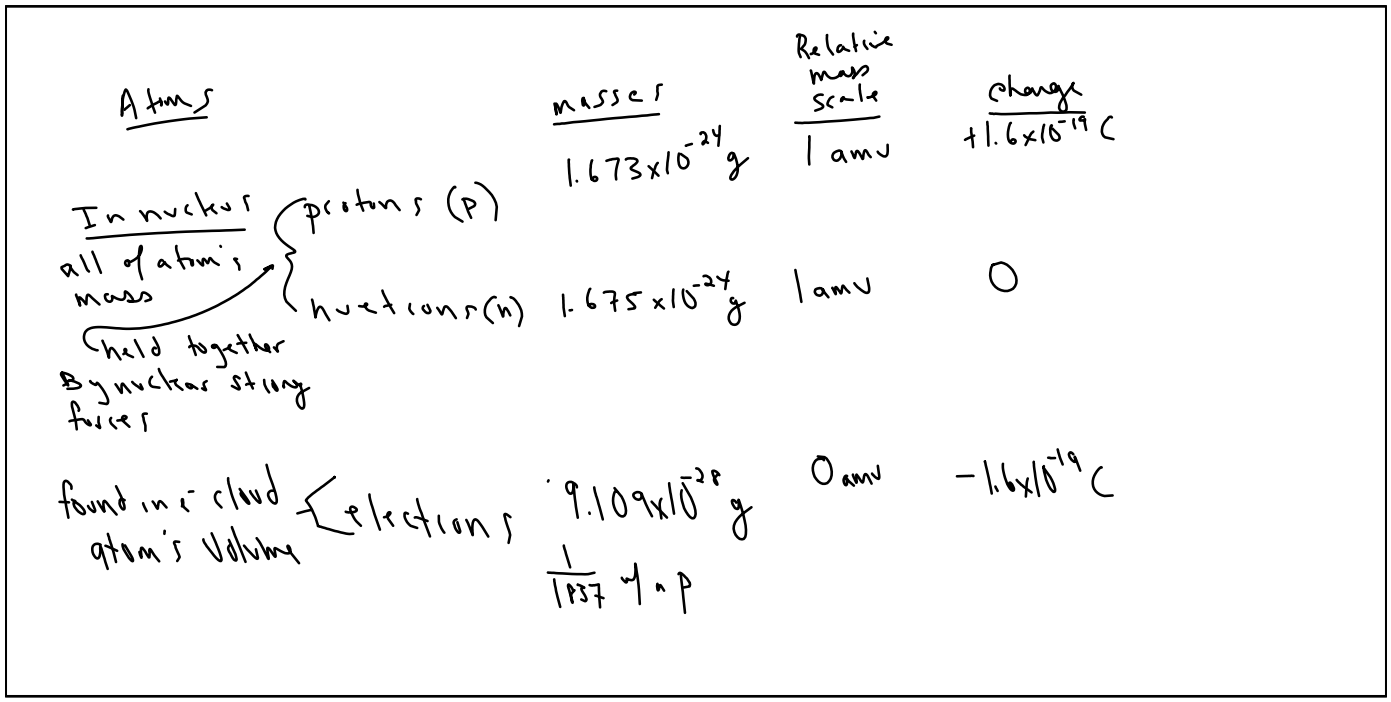

Atoms
masses
Relative mass scale
1.673x10^-24 g
1 amu
atomic mass unit
1 amu = 1.66x10^-24 g
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
neutrons (n)
1.675x10^-24 g
1 amu
found in e- cloud
atom's volume
electrons

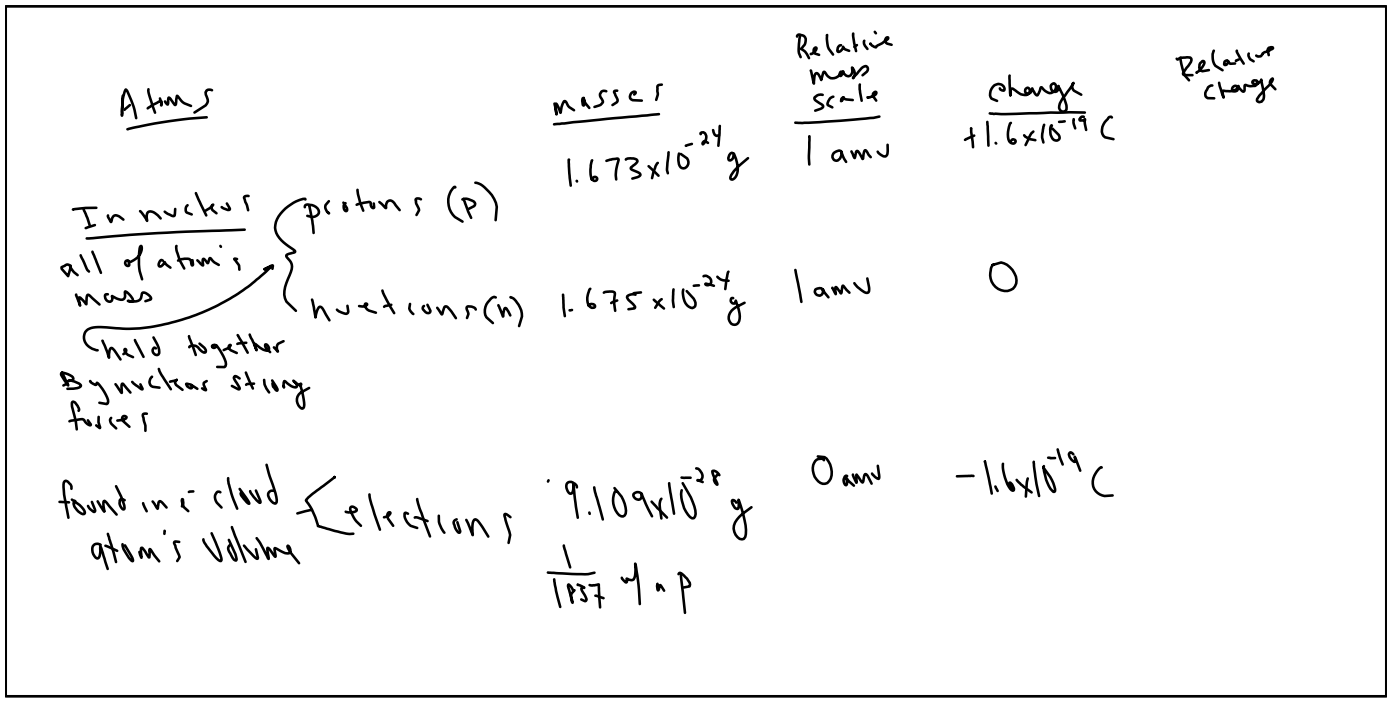

Atoms
masses
Relative mass scale
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
1.673x10^-24 g
1 amu
neutrons (n)
1.675x10^-24 g
1 amu
found in e- cloud
atom's volume
electrons
9.109x10^-28 g
atomic mass unit
1 amu = 1.66x10^-24 g

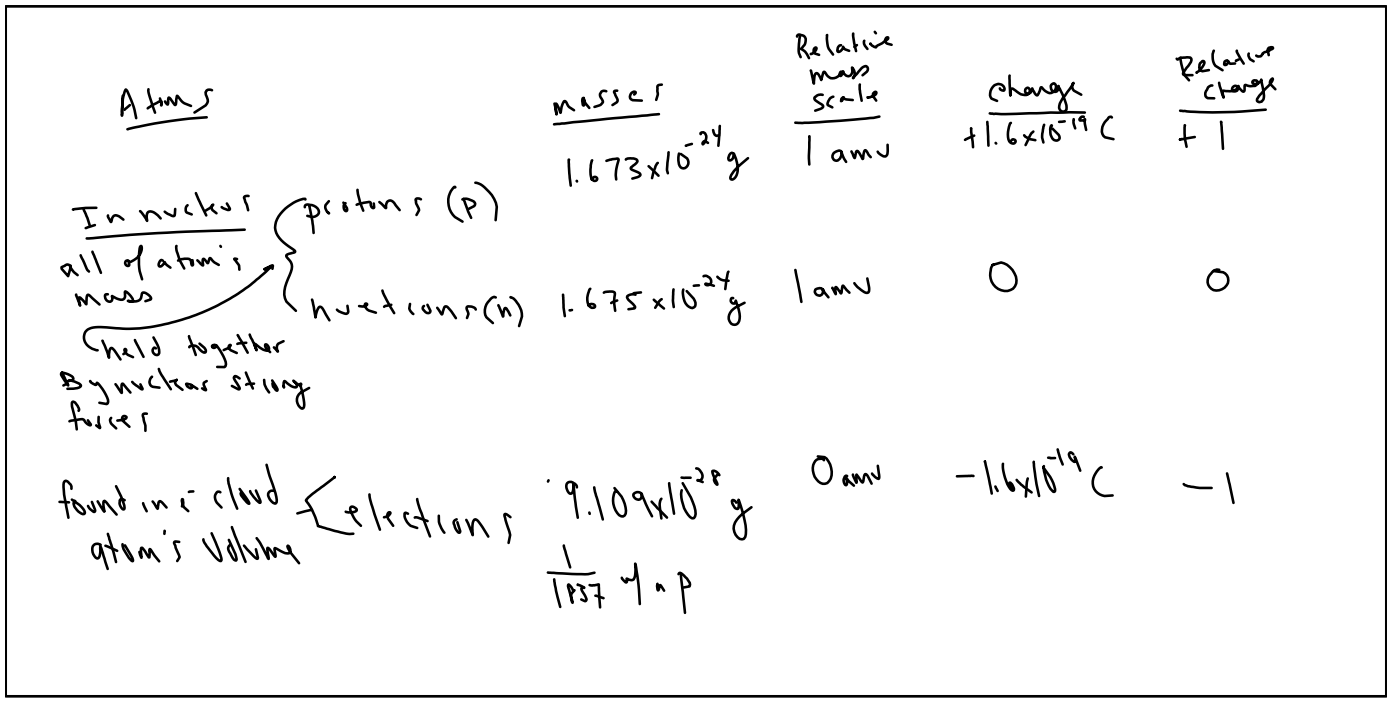

Atoms
masses
Relative mass scale
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
neutrons (n)
1.673x10^-24 g
1.675x10^-24 g
1 amu
1 amu
found in e- cloud
atom's volume
electrons
9.109x10^-28 g
1/1837 m_p
0 amu
atomic mass unit
1 amu = 1.66x10^-24 g


Atoms
masses
Relative mass scale
charge
1.673×10^{-24} g
1 amu
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
neutrons (n)
1.675×10^{-24} g
1 amu
found in e⁻ cloud
atom's volume
electrons
9.109×10^{-28} g
$\frac{1}{1837}$ m p
0 amu
-1.6×10^{-19} C

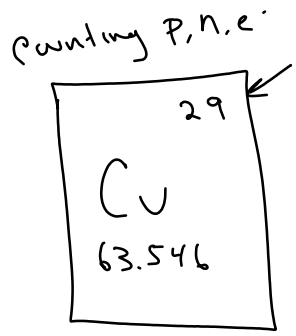

Atoms
masses
Relative mass scale
charge
In nucleus
all of atom's mass
protons (p)
1.673×10^{-24} g
1 amu
$+1.6 \times 10^{-19}$ C
neutrons (n)
1.675×10^{-24} g
1 amu
held together by nuclear strong forces
found in e⁻ cloud
atom's volume
electrons
9.109×10^{-28} g
$\frac{1}{1837}$ m p
0 amu
-1.6×10^{-19} C

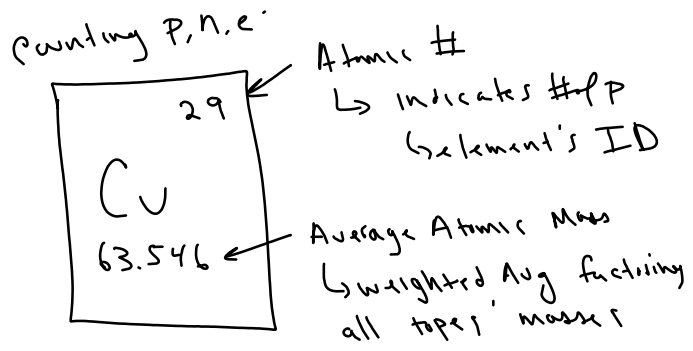

Atoms
masses
Relative mass scale
charge
1.673×10^{-24} g
1 amu
$+1.6 \times 10^{-19}$ C
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
neutrons (n)
1.675×10^{-24} g
1 amu
0
found in e⁻ cloud
atom's volume
electrons
9.109×10^{-28} g
$\frac{1}{1837}$ m p
0 amu
-1.6×10^{-19} C

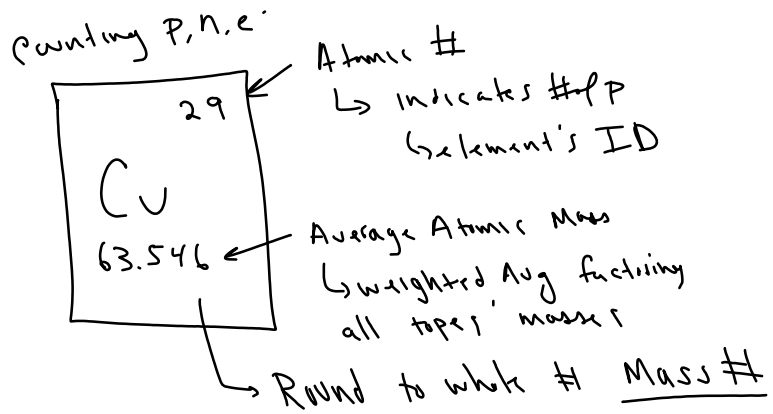

Atoms
masses
Relative mass scale
charge
Relative charge
1.673×10^{-24} g
1 amu
$+1.6 \times 10^{-19}$ C
In nucleus
all of atom's mass
protons (p)
neutrons (n)
1.675×10^{-24} g
1 amu
0
held together by nuclear strong forces
found in e⁻ cloud
atom's volume
electrons
9.109×10^{-28} g
$\frac{1}{1837}$ m p
0 amu
-1.6×10^{-19} C

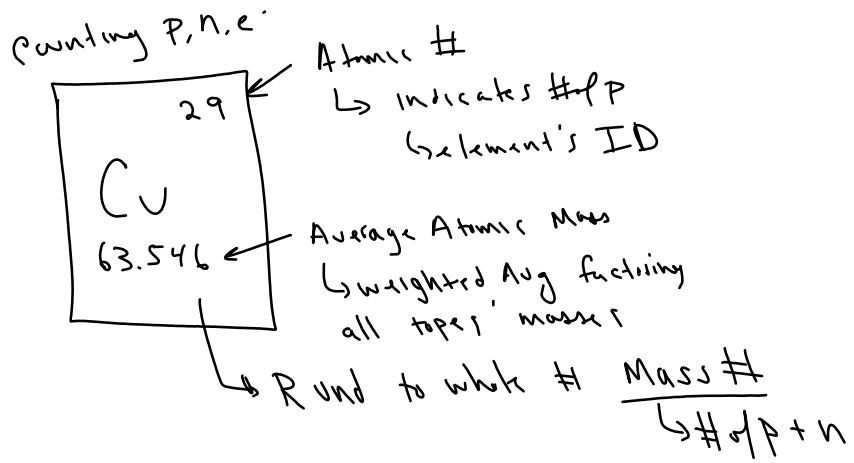

Atoms
masses
Relative mass scale
charge
Relative charge
In nucleus
all of atom's mass
held together by nuclear strong forces
protons (p)
1.673×10^{-24} g
1 amu
$+1.6 \times 10^{-19}$ C
+1
neutrons (n)
1.675×10^{-24} g
1 amu
0
0
found in e⁻ cloud
atom's Volume
electrons
9.109×10^{-28} g
$\frac{1}{1837}$ m p
0 amu
-1.6×10^{-19} C
−1

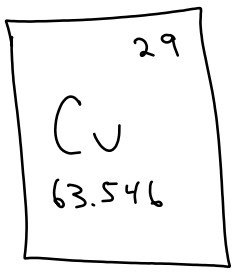
counting p, n, e⁻


counting p, n, e
29
Cu
63.546


counting p, n, e⁻
29
Cu
63.546
Atomic #
↳ indicates # of p
↳ element's ID
Average Atomic Mass
↳ weighted Avg factoring
all types' masses


counting p, n, e⁻
29
Cu
63.546
Atomic #
↳ indicates # of p
↳ element's ID
Average Atomic Mass
↳ weighted Avg factoring
all types' masses
↳ Round to whole # Mass #

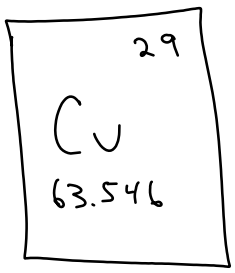

counting p, n, e⁻
29
Cu
63.546
Atomic #
↳ indicates # of p
↳ element's ID
Average Atomic Mass
↳ weighted Avg factoring
all types' masses
Round to what #
Mass #
↳ # of p + n



# of p = Atomic #

# of n = Mass # − Atomic #

# of e⁻ → for atoms (no charge)
# of p = # of e⁻

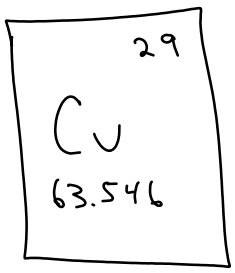


# of p = Atomic #

# of n = Mass # − Atomic #

# of e⁻ → for atoms (no charge)
# of p = # of e⁻

for ions (charged atoms)
+ ions (cation)
↳ lose e⁻
# of e⁻ lost based on charge



# of p = Atomic #

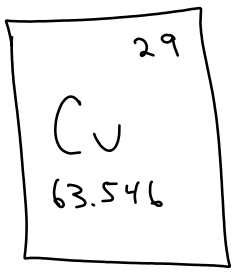
# of n = Mass # − Atomic #

# of e⁻ → for atoms (no charge)
# of p = # of e⁻

for ions (charged atoms)

+ ions (cation)
↳ lose e⁻
# of e⁻ lost based on charge

− ion (anion)



# of p = Atomic #

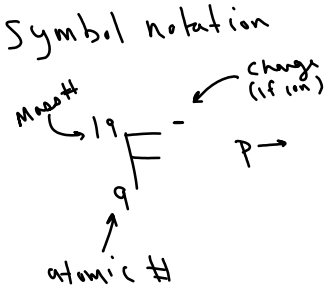
# of n = Mass # − Atomic #

# of e⁻ → for atoms (no charge)
# of p = # of e⁻

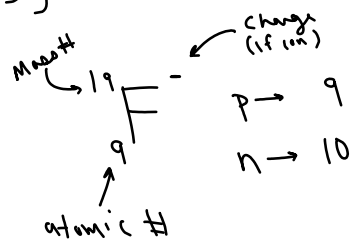
for ions (charged atoms)

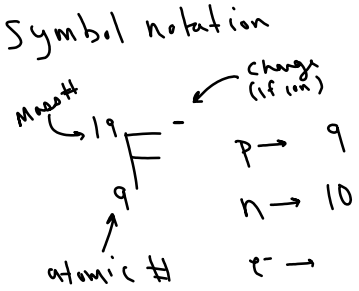
+ ions (cation)
↳ lose e⁻
# of e⁻ lost based on charge

− ion (anion)
↳ gain e⁻
# of e⁻ gained based on charge

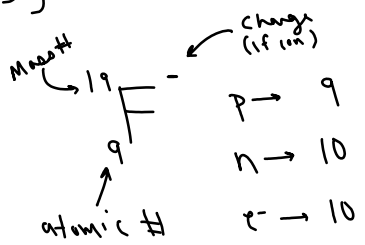

Symbol notation
mass #
19
F
9
atomic #
charge (if ion)
-
p

Symbol notation

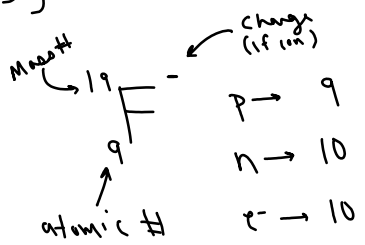



Symbol notation
mass #
19
9
atomic #
charge (if ion)
-
p → 9
n → 10
e⁻ →

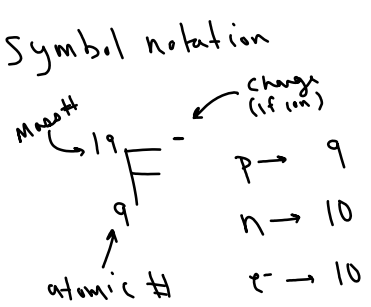
Symbol notation

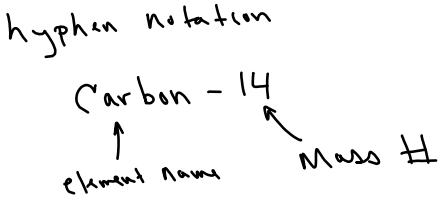


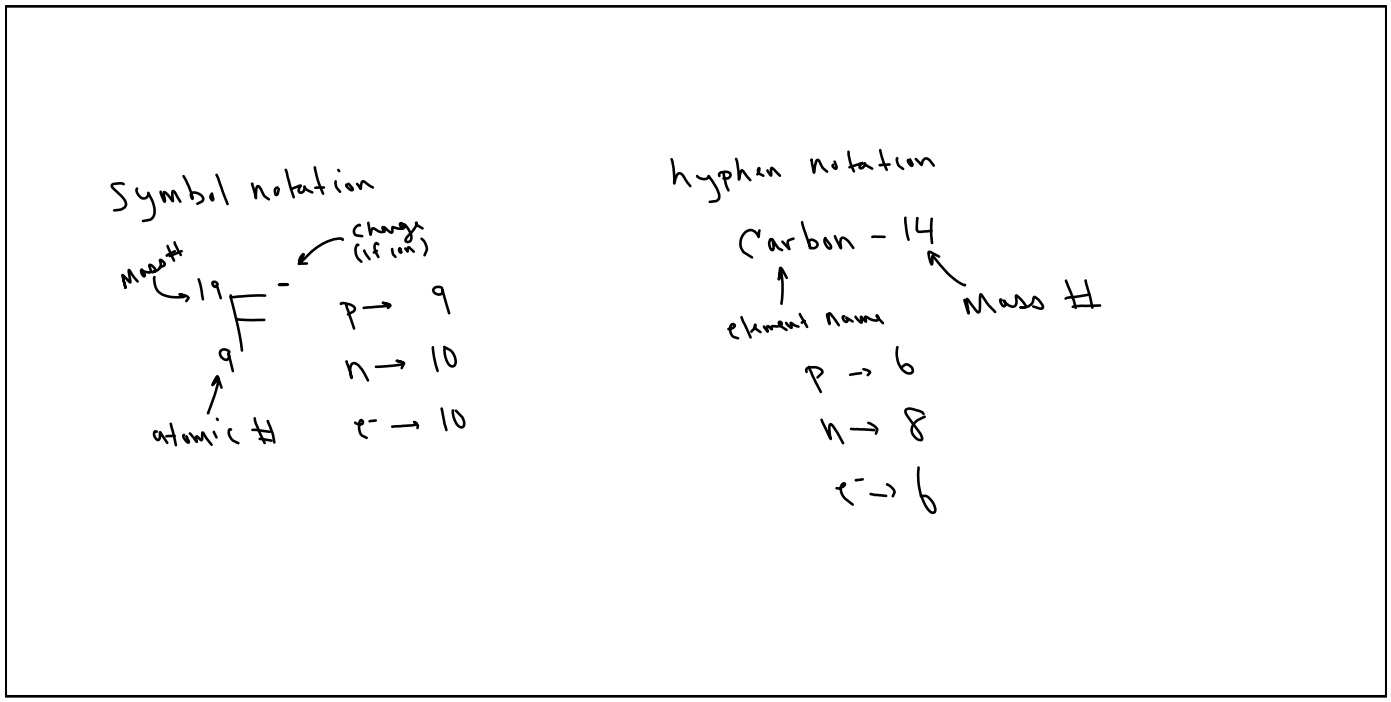
Symbol notation



hyphen notation


Symbol notation
mass #
19
charge (if ion)
-
F
9
atomic #
p → 9
n → 10
e⁻ → 10


hyphen notation
Carbon - 14
element name
Mass #


Symbol notation
mass #
19
F
9
atomic #
charge (if ion)
-
p → 9
n → 10
e⁻ → 10
hyphen notation
Carbon - 14
element name
Mass #
p → 6
n → 8
e⁻ → 6

? n e⁻

Boron

Na^+

P^{3-}

	?	n	e⁻
Boron	5	6	5

Na^{+}

P^{3-}

Average atomic Mass

Copper - 63

Copper - 65

Average atomic Mass

Copper - 63

Copper - 65

Avg Mass → 63.546 amu

Average atomic Mass → weighted Avg that factors in % abundance of each isotope.

	mass	% abundance	
Copper - 63	62.929 amu	9.17 %	Avg mass = (mass tope.)(%)$_1$ + (mass tope$_2$)(%
Copper - 65	64.927 amu	30.83 %	

Avg Mass → 63.546 amu

Average atomic Mass → weighted Avg of factors in % abundance of each isotope.

	mass	% abundance
Copper - 63	62.929 amu	9.17 %
Copper - 65	64.927 amu	30.83 %

Avg mass → 63.546 amu $(62.929\text{amu})(0.6917) + (64.927\text{amu})(0.3087)$

Average atomic Mass → weighted Avg of factors in % abundance of each isotope.

	mass	% abundance
Copper - 63	62.929 amu	9.17 %
Copper - 65	64.927 amu	30.83 %

Avg mass = (mass tope.)(%)$_1$ + (mass tope.)(%)

Avg Mass → 63.546 amu

(62.929 amu)(0.6917) + (64.927 amu)(0.3087)

Avg Mass = 63.545 amu

Isotopes of H

$^{1}_{1}H$ Protium

			p	n	e^-
Isotopes of H	$_1^1H$	Protium	1	0	1

			p	n	e^-
Isotopes of H	^1_1H	Protium	1	0	1
	^2_1H	Deuterium	1	1	1

			p	n	e^-
Isotopes of H	$^{1}_{1}H$	Protium	1	0	1
	$^{2}_{1}H$	Deuterium	1	1	1

			p	n	e⁻
Isotopes of (Avogadro's #)	$^{1}_{1}H$	Protium	1	0	1
	$^{2}_{1}H$	Deuterium	1	1	1

Molar Mass - Mass of 1 mol of a substance

for an element → Atomic Mass in $\frac{g}{mol}$

			p	n	e⁻
Isotopes of (Avogadro's #)	$^{1}_{1}H$	Protium	1	0	1
	$^{2}_{1}H$	Deuterium	1	1	1

Molar Mass - Mass of 1 mol of a substance

for an element → Atomic Mass in $\frac{g}{mol}$

for C → 12.01 $\frac{g}{mol}$

mass ⟷ mol ⟷ atom

62.3 g Al = ? mol Al

mass ⟷ mol ⟷ atoms

$62.3\ g\ Al = \frac{?}{}\ mol\ Al$

$62.3\ g\ Al \times \frac{1\ mol\ Al}{26.98\ g\ Al} = 2.31\ mol\ Al$

mass ⟷ mol ⟷ atoms

62.3 g Al = ? mol Al = ? atoms Al

$$62.3\ g\ Al \times \frac{1\ mol\ Al}{26.98\ g\ Al} = 2.31\ mol\ Al$$

mass ⟷ mol ⟷ atoms

62.3 g Al = ? mol Al = ? atoms Al

$$62.3\ g\ Al \times \frac{1\ mol\ Al}{26.98\ g\ Al} = 2.31\ mol\ Al$$

1.03×10^{22} atm s K

1.03×10^{22} atm s K : ? mol

: ? g

1.03×10^{22} atms K = ? mol

= ? g

1.03×10^{22} atms K $\times \frac{1 \text{ mol/K}}{6.022 \times 10^{23} \text{ atms K}}$

1.03×10^{22} atoms K = ? mol

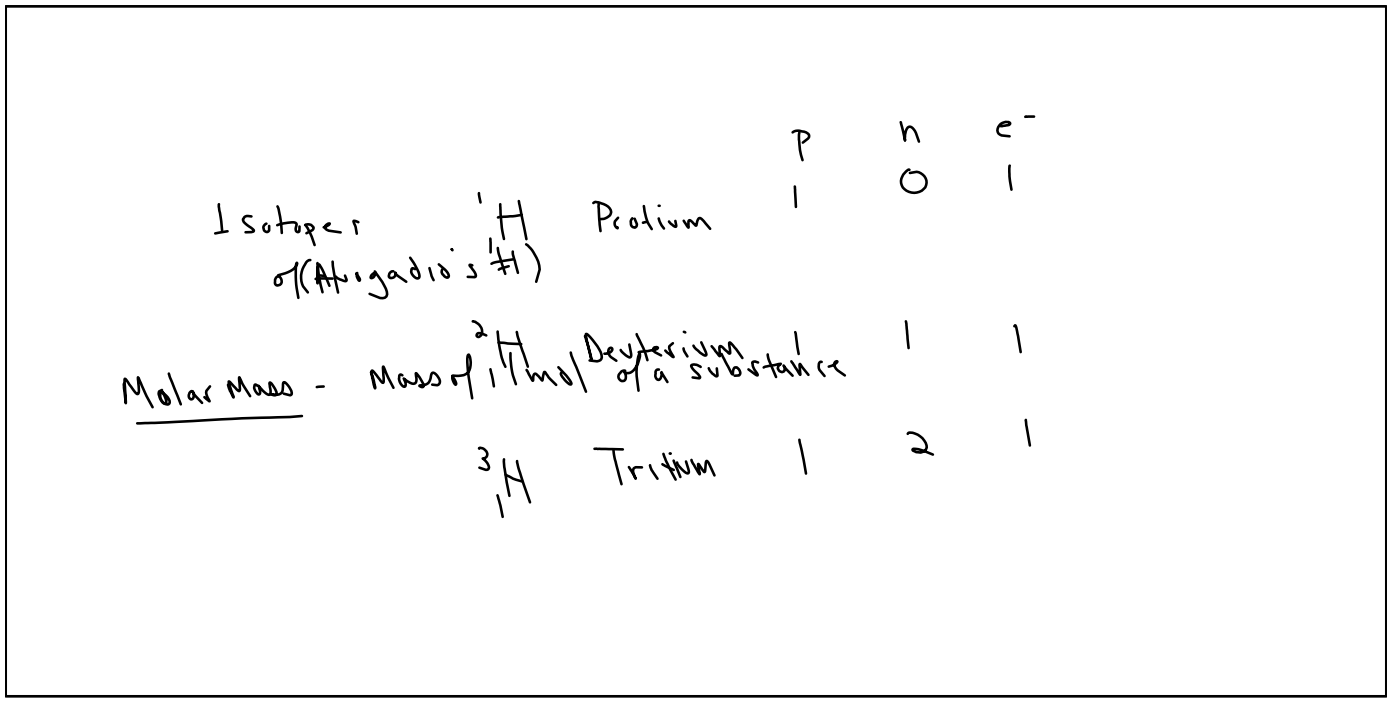
= ? g

1.03×10^{22} atoms K $\times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms K}} = 0.0171 \text{ mol K}$

1.03×10^{22} atoms K = ? mol

= ? g

1.03×10^{22} atoms K $\times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}}$ K = 0.0171 mol K


p n e⁻
Isotopes of (Hydrogen's #)
$^{1}_{1}H$ Protium 1 0 1
$^{2}_{1}H$ Deuterium 1 1 1
$^{3}_{1}H$ Tritium 1 2 1
Molar Mass - Mass of 1 mol of a substance